STUDIES OF TECHNICAL CHANGE

by

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Abstract

This thesis explores a number of questions related to the factors that influence productivity and technological progress at both aggregate and micro-levels. The main contribution of the current work is its attempt to relate all the studies to developing and transition countries in Eastern Europe.

The first chapter develops an endogenous growth model of sector productivity growth that accounts for varying levels of IPR protection usually present in developing and transition countries. One and two-country versions of the model are explored to show how the results change in the presence of international trade, when one country is a technology producer and another a technology consumer. The main finding of the model suggests that in the presence of international trade with a knowledge-producing country, low levels of IPR protection lead to higher levels of sector productivity growth in a technology-consuming country.

The second chapter empirically assesses microeconomic exporting-productivity links using the data for Ukrainian manufacturing firms for the years 2000-2005.

The results of the estimation show that firms with higher total factor productivity (TFP) in the period prior to entry are much more likely to enter export markets. Age, size and intangible assets of the firm also have significant positive influence on the probability of exporting. Testing of the learning-by-exporting effect is implemented with the use of the propensity score matching technique to address the issues of endogeneity and sample selection. The results for the whole universe of firms in the dataset go in line with common trends, and suggest significant positive post-entry productivity effect. At the industry level, the results confirm the presence of the learning-by-exporting effect in most of the industries included in the analysis.

The third chapter concentrates on continuous exporters to study the impact of the type of export dynamics on the firm-level changes in the TFP. The estimation is performed for different types of export markets and products. The results of the analysis confirm that exporting to the more technologically advanced countries results in higher productivity gains as a result of the access to new superior technologies and better managerial practices. Productivity gains can also be higher when capital intensive products are exported to the economically advanced markets.

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Glossary

CDF	Cumulative Distribution Function
IP	Intellectual Property
IPR	Intellectual Property Rights
GDP	Gross Domestic Product
GMM	General Method of Moments
GPT	General Purpose Technology
FAME	Forecasting Analysis and Modelling Environment
FDI	Foreign Direct Investment
FE	Fixed Effects
IV	Instrumental Variable (Approach)
LP	Levinsohn-Petrin (Technique)
NACE	Classification of Economic Activities in the European Community
NAFTA	North American Free Trade Agreement
OECD	Organisation of Economic Cooperation and Development
OLS	Ordinary Least Squares
OP	Olley-Pakes (Technique)
R&D	Research and Development
TFP	Total Factor Productivity
TRIPS	Trade Related Intellectual Property Rights
UAH	Ukrainian Hryvna
UNESCO	United Nations Educational Scientific and Cultural Organisation
USD	United States Dollar
VAT	Value Added Tax
WTO	World Trade Organisation

Chapter 1. Introduction

This thesis aims to answer a number of questions related to the factors that influence productivity and technological progress at both aggregate and micro-levels. The main contribution of the current work is its attempt to relate all the studies to developing and transition countries in Eastern Europe.

Economic growth depends on a variety of factors, including rates of population growth, savings rates, efficiency of resource allocation and use, organizational practices, development of new technologies and others.

Productivity is the main driver of economic growth and development. Increase in productivity means increase of output and consequently income per unit of input. Profits resulting from higher levels of productivity can be beneficial to all groups of economic agents: workers get better wages and possibly more leisure time, shareholders obtain higher dividends and consumers benefit from lower prices. At the national level, higher productivity leads to higher living standards as a result of more real income being generated in the economy, which raises consumption levels, increases leisure time and adds to social government spending. Productivity measures have gained a role of key indicators of economic performance and much effort has been made recently to conduct international comparisons. The Annual Compendium of Productivity Indicators published by the OECD includes both labour and multi-factor measures of productivity [1].

As observed by Krugman [2], “Productivity isn't everything, but in the long run it is almost everything. A country's ability to improve its standard of living over time depends almost entirely on its ability to raise its output per worker. World War II veterans came home to an economy that doubled its productivity over the next 25 years; as a result, they found themselves achieving living standards their parents had never imagined. Vietnam veterans came home to an economy that raised its productivity less than 10 percent in 15 years; as a result, they found themselves living no better - and in many cases worse - than their parents”

Until recently, however, neoclassical theory considered capital accumulation as a main source of economic growth, while technological progress has been treated as an exogenous process determined by the time trend. Only relatively recent studies by

Romer (1990) and Grossman and Helpman (1991) have explored the importance of commercially oriented research and development (henceforth R&D) expenditures as a main factor of technological and productivity growth. The main idea of these studies is that new inventions streaming from R&D expenditures add to the cumulative stock of knowledge, which in turn affects national productivity level. Griliches (1988) and Coe and Moghadam (1993) have also provided sound empirical evidence that cumulative domestic R&D is an important factor determining productivity.

Moreover, in a globalized world, all countries are extensively involved in international exchange in goods, services and ideas, in the form of trade, foreign direct investment, new knowledge and technologies, production processes, organization and managerial practices. This means that the productivity level of any country open to trade should also depend on the R&D efforts of its trading partners. In addition, higher levels of domestic R&D capital stock increase country's ability to absorb R&D benefits of its trading partners, thus raising its aggregate productivity level.

This aspect has been studied by Eaton and Kortum (1996), who showed that a country's relative levels of productivity determine its ability to innovate and make use of new technology. Estimating the model for the majority of the OECD countries, the authors have found that more than 50% of the growth in each country in the sample stems from innovation in the three main innovative countries: the United States, Germany and Japan. These three countries, along with France and the United Kingdom, derive more than 10% of their growth from research done at home. The same argument is made by Coe, Helpman and Hoffmaister (1997) and Parente and Prescott (2002) who conclude that R&D spillovers from industrial to less developed countries are substantial and play a major role in the productivity growth of the latter.

The main conclusion of the above discussion is that productivity growth in every country depends on domestic as well as foreign innovative efforts, where the former are disseminated within the country and the latter are adopted from its trading partners. Moreover, technologies adopted from abroad are especially important for productivity growth in developing countries with low levels of domestic R&D expenditures and capital stock of knowledge. Connoli (2003) provided convincing empirical evidence that imports of foreign technology from industrialized countries contribute more to the GDP growth of developing countries than domestic innovation.

However, imitation of foreign technologies that has given boost to economic growth in a number of developing countries (the most striking examples include the countries of East Asia) has raised many complaints in the developed world. Indeed, main technology producers seek to strengthen the protection of intellectual property rights (henceforth IPR) in their trade partners in emerging markets.

In response to these requirements, the World Trade Organisation (WTO) has developed and adopted an algorithm for international harmonisation in intellectual property (henceforth IP) protection in the form of trade-related aspects of IPR agreement (TRIPS). According to the TRIPS agreement, all members of the WTO are obliged to obey the minimum standards of IPR protection for a wide range of issues.

Many emerging market economies, such as Mexico, Brazil, China, India, Vietnam, Indonesia and many countries of Eastern Europe, have committed to meeting the requirements of the TRIPS agreement and have been working on bringing their national legislation in line with the required standards. However, as noted by Shen (2005) [3], "today their IP protection practices are still far from achieving the level demanded by multinational corporations and the West…Problems arise owing to malfunctioning of enforcement mechanisms, which is caused by the lack of IP expertise in academic institutions; a shortage of legal professionals within the national litigation system; and more crucially - by a low awareness and understanding of IP even amongst key stakeholders, not to mention the general public (Leesti and Pengelly, 2002)". Sometimes, however, the lack of enforcement of IPR protection constitutes a part of tacit government policies targeted at increasing national productivity growth.

Despite the convincing empirical evidence, several theoretical studies of sector productivity growth treat technological change as exogenous stochastic time process. This implies that economic growth in a modelled economy depends predominantly on the technologies developed from domestic sources. In addition, such a model structure assumes the presence of the legislative and institutional environment that allows private property protection and specific institutions managing the invention process. The results of such studies are hard to interpret for the small economies characterised by the high degree of trade openness, and hardly any policy implications can be derived for developing and emerging economies.

Chapter 2 of the thesis attempts to develop an endogenous growth model of sector productivity that accounts for the varying levels of IPR protection usually present in developing and transition countries. The initial hypothesis is that higher level of IPR protection in a country of interest would lead to higher productivity growth, which is certainly the case for technology-producing countries. There are some doubts, however, if this conclusion would hold for a case of a technology-importing country.

To study this phenomenon, Chapter 2 presents a model of a monopolistically-competitive industry in a country that does not invest in innovation and depends entirely on technologies produced by the rest of the world. The first version of the model studies the impact of the IPR protection rate on the sector productivity growth in a closed economy. The second version contains a two-country setting and shows how the results change in the presence of international trade, when one country is a technology producer and another a technology consumer.

The main finding of the model suggests that, in the presence of international trade with a knowledge-producing country, low levels of IPR protection lead to higher levels of sector productivity growth in a technology-consuming country. The main conclusion of the chapter is that the national level of IPR protection plays an important role in sector productivity growth. Moreover, high levels of IPR protection can have an adverse impact on the productivity and consequently economic growth in developing countries.

Chapter 3 studies the linkages between international trade and productivity at the level of individual firms on the basis of the database covering the main output sectors of the Ukrainian economy for the period 2000-2005. As discussed above, there are many channels through which international activity could be beneficial to the productivity growth of the firm and of the country.

In particular, this chapter empirically tests two supplement hypotheses of the causal link between export activity and productivity. The first is the self-selection hypothesis. It implies that only more productive firms manage to enter and successfully operate in foreign markets owing to the significant amount of investments required to engage in international trade. The second hypothesis implies an additional increase in productivity of exporters owing to the learning effect that arises from operating in international markets. It is logical that exporters enjoy benefits of the so-called learning-by-exporting effect as a result of better access to new knowledge and technical expertise through their international contacts.

The importance of these hypotheses in explaining productivity differences between exporting and non-exporting companies has been addressed in a number of theoretical as well as empirical studies, including those of Bernard and Jensen (1999), Clerides, Lach and Tybout (1998), Aw and Hwang (1995), Delgado, Farinas and Ruano (2002), Baldwin and Gu (2003), Harris and Li (2007) and others. All authors have found strong empirical evidence in favour of the self-selection hypothesis and much less empirical support for the learning-by-exporting hypothesis.

The work presented in Chapter 3 makes several contributions to the literature on the linkages between trade and productivity. First the study makes use of the unique firm-level dataset from Ukraine covering the main Ukrainian manufacturing and service sectors during the period 2000-2005. Second, it uses several total factor productivity (henceforth TFP) estimation techniques that allow resolving methodological issues of endogeneity and sample-selection that usually emerge when estimating TFP. Third, the estimation of learning-by-exporting effect is performed using the propensity score matching approach, which addresses the *self-selection* bias that is common for the micro-level estimations of the linkages between exporting and productivity using micro level data.

Chapter 4 further explores the relations between firms' exporting activity and productivity performance, widening the scope of study to explore export dynamics at the intensive margin[1].

Recent theoretical findings imply that entries and exits from the export markets may not play a major role in the patterns of aggregate export dynamics, whereas the relationship between productivity performance and export dynamics at the intensive level deserves much closer attention.

Chapter 4 uses the same dataset of Ukrainian firms, and concentrates on the four main export-oriented industries to study the export dynamics and TFP growth at the micro-level, with the focus being made on the analysis of the export dynamics at the intensive margin.

This chapter starts with the analysis of structure of export distribution of the four selected industies during the period 2000-2005. Furthermore, the chapter implements Haltiwanger (1997) productivity growth decomposition along the lines of Harris and Li

[1] Intensive margin is defined as changes in export volumes of continuing exporters.

(2009) to see contribution of different subgroups of firms to aggregate industry productivity growth, distinguishing between exporters and non-exporters.

The last section of Chapter 4 concentrates on continuous exporters and studies the impact of the type of export dynamics (increase/decrease in export intensity) on the firm-level changes in the TFP. Furthermore, the estimation is performed for different types of export markets, e. g. countries of the European Union (henceforth EU) and countries of the Commonwealth of Independent States (henceforth CIS), and different types of export products, distinguishing between capital- versus labour-intensive products and raw materials. Such partitioning allows us to test the hypothesis that an increase in exports to the more technologically advanced markets leads to considerable gains in the productivity of exporters, especially when exports consist predominantly of capital-intensive products.

This dissertation has explored some of the factors which, by influencing productivity at micro-level, increase national levels of productivity growth and economic development. Overall, the analysis presented in this dissertation opens a number of directions for further theoretical and empirical research.

Chapter 2. Modelling Technology Policy and Growth for a Technology Importer

2.1. Introduction

The topic of productivity growth has become increasingly popular in the literature relating to modern trade. Several trade models have tried to determine the main factors of productivity growth in open economies. Most of the recent research studies in the area have shown that a firm's productivity in a sector is determined by two main factors: the first is the firm's own investment in commercially oriented research and development activities, and the second one is free spillovers of knowledge arising from the same kind of investment done by other domestic and foreign firms[2]. Knowledge spillovers play an important role in the productivity growth rate at micro-level, as they are admittedly one of the main channels of technology diffusion. In an open economy, knowledge spillovers associated with international trade come in the form of the three main channels (Grossman and Helpman, 1991). First, international trade allows an increase in the variety of intermediate inputs and capital equipment used in the production process (learning-by-importing). Second, it provides access to the new production methods, managerial practices and product designs, which in turn leads to better use of local resources and better product mix, and finally results in higher productivity (learning-by-exporting). Third, international trade gives an opportunity to imitate foreign technologies and adjust them to domestic production, which is especially important for less developed countries. International trade eventually increases a country's productivity in imitating foreign technologies or developing new ones, thus raising the country's productivity level.

However, numerous studies aimed at exploring the link between knowledge-producing activities in the form of R&D and sector productivity growth still possess a number of limitations that make it difficult to relate their conclusions to the real world. Most of the models have treated technological change as an exogenous stochastic time process. Such a model structure implicitly assumes an industrialised economy whose growth depends to a major extent on the technologies developed from the country's own sources. In addition, such a model structure would imply the presence of a legislative and institutional environment allowing private property protection (including IPR protection) and the presence of specific institutions managing the invention process.

[2] Refer to Grossman and Helpman (1991b) for an extensive discussion of open-economy models of endogenous growth.

These limitations are, in some sense, common to most of the literature on economic growth. However, the results of these studies make it difficult to develop any policy implications in relation to those countries of the developing world characterised by poor legislative systems, low levels of R&D investment and consequently knowledge production. It is also hard to interpret the model results for the small economies characterised by a high degree of trade openness and dependant to a high extent on foreign technologies.

Indeed, as noted by Coe, Helpman and Hoffmaister (1997) [4] "almost the entire R&D activity in the world is concentrated in the industrial countries. In 1990, the industrial countries accounted for 96% of total world R&D expenditures (UNESCO, 1993). Moreover, in 1991 within the OECD the seven largest economies accounted for 92% of R&D." This casts some doubt on the sphere of applicability of the endogenous growth model structure to less developed countries with low levels of R&D activities.

There is a scarce amount of theoretical literature adapting an endogenous growth model for a knowledge-consuming, non-innovating country that depends on foreign knowledge spillovers. The main distinguishing features of these countries include low levels of IP protection, imperfect legislative and enforcement systems, and low levels of R&D activities. Thus productivity growth in such countries is - to a high extent - driven by the illegal adoption of foreign technologies. Moreover, poor enforcement of IPR protection can be a part of government policy, aimed at supporting domestic producers in the infringement sectors.

Numerous world examples of the deliberate under-protection of IPR at government level, especially in the countries of developing world, support our hypothesis[3]. In this sense, developing an endogenous technological growth model for a technology-importing country will shed some light on the reasons behind these patterns of government policies, while providing some incentives for possible changes in legislation towards stronger IPR protection.

Thus the current chapter presents an attempt to develop an endogenous growth model exploring the links between R&D and productivity growth for a technology-importing country. The null hypothesis of our model implies that a higher level of IPR protection

[3] Deliberate under-protection of the IPR leading to a wide infringement of foreign technologies was the main driver behind the economic growth of such countries as Japan, China, and other economies of East Asia.

in a country of interest would lead to higher productivity growth. This is certainly the case for technology-producing countries. It is doubtful, however, whether the same conclusion would hold if the country under study was not a technology producer.

To study this phenomenon, the current chapter examines a monopolistically-competitive industry in a country that does not invest in innovation and depends entirely on technologies produced by the rest of the world. Two versions of the model explore a closed economy and a two-country setting to show how the results change in the presence of international trade. The main finding of the model suggests that, in the presence of international trade with a knowledge-producing country, low levels of IPR protection lead to higher levels of sector productivity growth in a technology-importing country.

The rest of the chapter is organized as follows. Section 2.2 presents a brief overview of the modern theory of economic growth. Section 2.3 summarises and discusses the main limitations of the modern growth theory. Section 2.4 presents a review of the relevant literature. Section 2.5 contains the background and motivation for theoretical modelling. Sections 2.6 and 2.7 present the model in autarky and in a two-country framework. Section 2.8 provides a comparative statics analysis. Section 2.9 concludes.

2.2. Development of the Modern Growth Theory

In the following section, I will try to provide a very brief overview of the models that signified major steps in the development of the modern theory of economic growth.

The first developments of the modern growth theory can be attributed to the middle of the twentieth century, to the *neoclassical growth models*. The first generation of neoclassical growth models (f. e. Solow (1956); Swan (1956)) shows that, in the absence of technological change and population growth, economic growth will eventually cease in the long term because of diminishing returns to the factors of production. Thus all the attempts to speed up economic growth by encouraging saving will fail in the long term, although in the short term an increase in the savings rate will temporarily raise the rate of capital accumulation. However, as noted by Atkinson (1969), in some cases the actual time of the short term may not be particularly short and can be as long as forty years.

The main features of the first generation exogenous growth models are aggregate production function with constant returns to scale in labour and capital, absence of population growth and constant technology (no technological change).

Under such conditions, the only remaining engine of economic growth is *capital accumulation*. Even with population growth, the model will achieve the same result of zero economic growth in the long term. The next step in the development of the economic growth theory was made by the introduction of the *exogenous technological change*. Intuitively, in such a model, the diminishing returns to capital accumulation are now continuously offset by technological progress, and in the long term the economy eventually reaches the state where two forces offset each other exactly, leading to the constant capital/labour ratio. Since the introduction of exogenous technological growth, many attempts have been made to endogenize it. Endogenous Growth Models represented a completely new class of models that allowed for one of the output determinants to grow in proportion to capital. This neutralizes the effect of diminishing returns, and makes output grow in proportion to capital as well. These models were called *AK models* with production function of the form $Y = AK$, with A - technology held constant.

The basic idea of the AK model was used by Romer (1986) to provide an analysis in terms of Ramsey's (1928) model of intertemporal utility maximization by a representative individual, who does not take into account externalities of new knowledge creation. Romer's contribution gained popularity after the article by Lucas (1988), and since then has been taken as a benchmark by the literature on modern endogenous growth.

The main results of the Romer models suggested that, in the case of constant social returns to capital, characteristics of the economy such as saving behaviour of individual consumers and size of the economy will affect long-term growth. The model also implied that, when optimizing their consumption path and capital accumulation, individuals and market agents do not internalize the effect of individual capital accumulation on knowledge, which leads to less than optimal equilibrium growth. Although the model has endogenized growth, it still relies on the external accumulation of knowledge. When rewards to technological progress have been endogenised, the model gained structural complexity moved away from perfect competition to the market structure of large individual firms[4]. Also, in case of constant returns to scale, cross country variations (in production function parameters and rates of population growth) might lead to permanent differences in the rates of economic growth. The last result of the Romer (1986) model suggested that the presence of the AK technology eliminates dynamic inefficiency despite the size of the capital stock. That is not the case in the neoclassical model, where there exists a possibility of "over accumulating" capital to the extent when the capital stock is very large and its marginal product is smaller than its marginal cost. This leads to "dynamic inefficiency", which can be eliminated by reducing the capital stock.

The main differences of the Solow-Swan (neoclassical) model and AK (endogenous growth) models are returns to capital and the determinants of the long-term growth rate (Aghion and Howitt, 1998). In the Solow-Swan model, growth rate is determined by population growth and technological change (both are exogenous to the model), while structural characteristics of the economy (number of firms and the rate of time preference) determine only the steady-state level of the per capita income. On the contrary, in the AK model, the structural characteristics of the economy display a strong influence on the long-term growth rates.

[4] Romer incorporated imperfect competition in a general equilibrium framework in his second model (1987, 1990).

Cross-country empirical studies by King and Levine (1993), Alesina and Rodrik (1994), Benhabib and Spiegel (1994) support the endogenous growth approach but not the AK model in particular, especially its predictions about convergence and dynamic returns to capital accumulation.

2.3. Limitations of the Modern Growth Theory

As discussed by Aghion and Howitt (1998), all the endogenous growth models possess a number of limitations. The first significant limitation includes assumptions that ensure the existence of the steady state with a balanced growth. These assumptions are common to the Schumpeterian approach as well as Romer's (1987, 1990) model of horizontal innovations and the vertical (quality ladders) model. These assumptions are quite strong and have been included only for tractability purposes. On the other hand, the Solow-Swan model with technological change requires a technical change to be purely labour-augmenting with a constant exponential rate of growth, and the Cass-Koopmans-Ramsey model requires a utility function to be iso-elastic in one parameter. These assumptions have to be included in those models, even after technology has been endogenized and there is no justification to think that they may apply.

These strong assumptions also omit important real life phenomena, such as stages that reflect the reallocation of resources from agriculture to manufacturing and then to services, with all three sectors possessing different requirements for factors of production and different technological dynamics. The second limitation is the way of inclusion of the knowledge parameter A into the production function. In all endogenous growth models, knowledge is treated like any other production factor, while in reality the creation of new knowledge takes place in the form of new ideas and inventions that do not exhibit constant growth rate. Another drawback of the majority of endogenous growth models is their way of modelling R&D activities as an output of one individual or a firm. In reality, relations between employers and inventors are much more complex and require much closer attention.

To summarise, let us turn to the discussion by Lipsey, Carlaw and Bekar (2005) who suggest that all models of technological change face a trade-off between generality and explanatory power. The more general the theoretical formulation, the less it is able to explain the situations for which specific conditions matter. This is one of the distinguishable features of all growth theories that significantly limit their explanatory power - they are developed in such a way that they apply at all times and all places. Also, despite the fact that growth possesses some universal characteristics that must be shared at all times by any theory, it is also influenced by specific characteristics that vary over time and space, and technology in its turn is far more complex so that its main characteristics could hardly be fully reflected by the general aggregate production function.

Endogenous-growth models of neoclassical tradition implicitly assume institutional circumstances, such as private property limited liability, rule of law, presence of specific institutions managing the invention process, and an implicit assumption about low population growth rate, that underpin modern market economies.

Thus, because of their structure, these models apply only to countries whose growth depends to a significant extent on the development of new technologies (both fundamental and derivative) from their own resources.

On the other hand, they cannot be applied to the countries whose growth depends to a crucial extent on the diffusion of technologies developed elsewhere. Nor do they apply to those economies whose GDPs are currently static and which seek conditions that would allow them to enter the period of sustained growth.

Thus the higher the explanatory power of the theory is and the more predictions it makes, the more restricted its range of applicability in both time and space.

Hence major controversies may arise when applying common structures of endogenous-growth framework to developing countries that can be characterised by the low levels of technological development, lack of Intellectual Property (IP) protection and the existence of a significant fringe sector. This issue has been widely discussed in the modern literature, and in what follows I will try to provide a brief overview of the related findings.

2.4. Literature Review

There is a vast amount of literature devoted to productivity growth, and it is becoming even more and more diverse. In the current review, we will focus on the strand of literature that explores mainly the influence of IPR protection on domestic innovation rates, R&D activities, technological development, and, as a consequence, economic growth via an increase in the amount of inward technology flows that come to developing countries with international trade[5] and investment.

It is reasonable to start with some literature that allows us to obtain a more detailed picture of the IPR. For example, the FRBSF Economic Letter discusses whether international patent protection can contribute to the growth of a developing country. Developing countries continuously argue that protection of IPR entails high costs to their economies: it is expensive to set up and enforce, and it significantly limits their abilities to copy technologies that may be essential for their economies and, more important, for public health reasons (patented medicines). However, international protection of IPR provides an extensive potential for dynamic benefits for developing countries. In particular, it may increase economic growth in these economies by increasing their domestic innovation rates, since IPR is a primary factor that increases incentives for innovators and improves productivity. Despite the fact that such an effect would occur first in developed countries, developing countries would follow eventually because of the spread of the new technologies.

Parente and Prescott (2002) make the same argument, supporting it with examples of South Korea, Japan and Taiwan which rebuilt their infrastructure by adopting the latest technologies from abroad and becoming among the fastest growing economies in the world. Technological diffusion may boost the economic growth of countries much faster than domestic investment in R&D and innovation, with the probable reason being that it is more costly to innovate domestically. For example, in his paper, Connoli (2003) finds that foreign technology imports from industrialized countries contribute more to the GDP growth in developing countries than domestic innovation.

[5] However, as argued by Young (1991), as a result of trading with more advanced economies, less developed countries may keep specializing in traditional production activities that generate little new knowledge. Another obstacle has to do with the existence of *clubs* (Quah (1996)), i. e. the clusters of countries that maintain research cooperation and exchange knowledge among them but not with the rest of the world.

It should be noted that the process of technological diffusion across the countries takes one of two forms. One might imitate foreign technology without paying for it or import it through licensing or through importing intermediate goods that embody new technology (for example through FDI). The first strategy is clearly less costly in the short term; however, in the long term it hinders technological advances that promote economic growth in developing countries.

The IPR do imply an increase in the market power of the IPR owners, which may have an adverse effect on market competitiveness. However, most growth economists agree that a certain level of patent protection is required to stimulate investment in knowledge and technology creation, especially in those industries where new technologies become public quickly[6]. Insufficient protection of IPR affects technological innovation and diffusion in both developed and developing countries. Under-protection of IPR by developing countries reduces profits in industrialized countries' firms; as a result, industrialized countries would engage in less R&D investment and less innovation, and consequently less technology flows to developing countries would occur. Thus, despite the fact that there might be some short-term benefits from imitation for developing countries, there are always the potential long-term costs of the overall slow-down of technology creation.

Many papers explore different types of endogenous economic growth models, based on the standard frameworks described in the section 2.2. In what follows, I would like to concentrate on some which tried to account for international differences in productivity levels as well as the levels of IPR protection.

Eaton and Kortum (1996) developed a model of growth and technology diffusion on the basis of the quality ladders model of innovation developed by Grossman and Helpman (1991). Then they fitted the model to the aggregate data from OECD countries. The model suggests equal growth rates across all the countries and determines relative productivity of each country by its ability to make use of new inventions. Thus, relative productivity levels determine a country's ability to innovate and adopt new technologies. Furthermore, the authors estimate the model (including the majority of OECD countries) that explains international patterns of productivity and patenting. They show that both a size of a country's economy and a size of its research community are highly correlated with its total inventive output, which depends on the domestic

[6] The example cited most frequently here is pharmaceuticals.

level of human capital, the country's trade relationships, and its proximity to other international sources of innovation. The authors have found that more than 50% of growth in each country in the sample stems from innovation in the three main innovative countries: the United States, Germany and Japan, and only these three countries, along with France and the United Kingdom, derive more than 10% of their growth from research done at home.

McCalman (2001) provides further insights into the relationship between IPR protection and international trade. The author quantifies the impact of international patent harmonization as implied by the TRIPS with the main purpose of estimating the value of income transfers between countries of the Uruguay Round. He estimates a structural model of the value of patent rights held by 29 countries, with the estimates taken from the modified version of the Eaton and Kortum (1996) model. The framework develops a quality ladders model that estimates the impact of innovations on productivity growth via the number of patent applications. To model patenting decision the author assumes a profit maximizing inventor, who applies for a patent only in those countries that provide sufficient patent protection. This allows the modelling of the relationship between enforcement institutions and the rents coming from patent protection. The nature of the model also allows the modelling of the experiment in which all countries adopt standard level of IP protection consistent with the TRIPS. Analysing the results of the experiment the author draws some conclusions about the international distribution of income as a result of the TRIPS agreement. However, the author conducted the exercise only for a certain set of innovations, disregarding the effect of any positive change in the number of innovations that might follow the adoption of TRIPS standards. The main conclusion stemming from the model is that international patent harmonization can generate large transfers of income between countries. The US is the major beneficiary: the author estimates net transfers to the US from the TRIPS agreement to be about 40% of the gains coming from trade liberalization. At the same time, developing countries suffer negative net transfers of 64% of the gains associated with trade liberalization.

One of the recent papers by Carlaw and Lipsey (2006) studies endogenous growth in a Structural-Evolutionary (S-E) framework. The authors built a model of General Purpose Technologies (GPT) driven growth, in which all production resources are shared amongst the three sectors of the economy under conditions of a perfect competitive environment. The first sector endogenously generates fundamental research to create a new GPT, another sector applies new fundamental research results to improve production methods of consumption goods, and finally the third sector is occupied by the production of consumption goods *per se*. The development path (future impact on productivity) of any given new GPT is not known at the time it arises; thus agents make maximization decisions with respect to current information about the marginal products of resources used in each sector. They are unaware of any spillover effects on marginal productivities that may result from their current allocation decisions. Growth is not constant in the model, since GPTs have different time periods to obsolescence and different productivity effects. That is why income growth rate is not constant from one GPT to another, the main reasons being the random rate of new GPT arrival, and the unknown potential productivity value of the new GPT.

Among the recent theoretical literature, another interesting paper is that by Minniti (2006), in which the author addresses the impact of knowledge spillovers on the innovative activity of the private firms. The theoretical model is based on the model devised by Smulders and van de Klundert (2004), and represents a model of endogenous growth where underinvestment in R&D is generated by technological knowledge spillovers between firms. This in turn results in a low economic growth and excessive firms' entry. In the model, private firms engage in process innovation with the purpose of cost reduction. And technological progress is measured by the average rate of cost reduction. Market structure is measured by the number of operating firms. Market structure and technological progress are jointly determined in equilibrium by the rate of economic growth. After comparing competitive and socially efficient outcomes, the author concludes that "in a dynamic framework, where market structure and growth are both endogenous, an economy under *laisser-faire* achieves very little growth compared with the social optimum; in addition, too many firms enter the market" [5].

Brecher, Choudhri, Schembri (1996) in their paper compare the rates of sectoral productivity growth for two trading partners of unequal size in the long term. The authors explore the issue in a setting of a monopolistically competitive industry characterized by a production function that shifts endogenously through national and international spillovers of knowledge. The authors assume national rate of knowledge spillover to be higher than international rate of knowledge spillover and distinguish between two versions of the model. The first version assumes that all knowledge produced in one country eventually spills over to the other country, while an alternative version implies that some part of the knowledge never spills over to the foreign country. According to the first version, despite the fact that small country may exhibit lower productivity level, countries' rates of sectoral productivity growth are equal in the long term. However, according to the alternative version of the model, which assumes that some part of knowledge never leaves national boundaries, the smaller country will experience a lower rate of sectoral productivity growth in the long term. The authors further test the model using identical sets of Canadian and US manufacturing sectors. First the authors use US and Canadian R&D stocks as a measure of aggregate knowledge stocks to estimate their effects on each country's productivity. According to the results the US R&D tend to have the same of even larger impact on Canadian then on the US productivity, which agrees with the basic version of the model. The authors further show that the ratio of the average long-term Canadian productivity and the US productivity tends to be equal to one, which also confirms the basic version of the model. The results of the empirical analysis suggest that despite significant differences in R&D sectors, the Canadian and US rates of sectoral productivity growth tend to converge to the rate of bigger country (US) in the long run.

The impact of international trade and production pattern on the aggregate productivity growth of developing countries was explored in the paper by Choudri and Hakura (2000). To incorporate the view that international trade facilitates technology transfer, the authors developed a multisector framework of Krugmans's (1985) technology gap model. They allowed the technology lag in a sector to be inversely related to the trade openness of the sector, which is based on its export and import intensity. The aggregate rate of productivity growth in the long term was calculated as a weighted average of sectoral growth rates with weights given by production shares [6]. The model was estimated using a panel data of 33 developing countries. The results of the empirical analysis confirmed that openness is an important determinant of sectoral growth rate; moreover its effect on productivity growth varies across sectors. Traditional manufacturing (low-growth) sectors experience little in any productivity effects associated with increased trade openness. At the same time, increased trade openness was confirmed to have a significant positive effect on sectoral growth rates in knowledge- and capital-intensive (medium- and high-growth) sectors. One of the policy implications discussed in the paper suggested that, in order to increase aggregate productivity growth, developing countries might try to stimulate production in the medium- and high-growth sectors. However, since import competition and export intensity are important determinants of the sectoral growth rate of those sectors, adopting such policies by restricting imports might have an adverse effect on sectoral as well as aggregate productivity growth.

Sa, Connolly and Peretto (2009) developed a North-South model of technological transfer. New product varieties are created in the North and technology is transferred to the South in the form of FDI, licensing or exports. The form of technology transfer depends upon the trade-offs between the benefits and costs of transferring technology to countries with limited IPR protection. Licensing - the best type of technology transfer leading to significant production cost reduction - might not always be beneficial in the less developed countries, owing to the high risks of imitation. The model implies that, overall, higher levels of IPR protection in the South would lead to a higher equilibrium level of technology transfer, leading to higher levels of welfare in developing countries. However, this effect applies only if the initial level of IPR protection in the South is above the certain threshold; otherwise an increase in the IPR protection may have an adverse effect.

To summarise the discussion, it should be noted that the problem of productivity and international technology transfer has undergone significant changes since a study by Melitz (2003). Extending Krugman's (1980) trade model, the author developed a dynamic industry model with heterogeneous firms to analyse the impact of international trade exposure on the inter-industry firm reallocations that lead to aggregate industry productivity growth. Following Melitz (2003), many recent theoretical papers have moved away from the growth models of a representative firm/agent, and started taking into account firm-level productivity differences to analyse industry productivity dynamics in an international setting.

2.5. Background and Motivation

From the review of the literature discussed in the previous section, one can classify the models into three broad categories. The first category includes the models that distinguish three sectors of the economy: sector producing consumption goods, and sectors of applied and fundamental research. The second category includes two sectors – the sector producing consumption goods and applied research sector. The most common category contains the models with one sector economy, in which private homogeneous firms simultaneously invest in R&D and produce consumption goods. However, none of the above models includes the fringe sector *per se*. In this aspect, there are two ways that can be proposed to introduce the problem of IPR protection. The imitative sector can be explicitly introduced into the model; alternatively, one can assume that imitation is a part of knowledge spillovers, as in the model of Minniti (2006) or in that of Brecher, Choudri and Schembri (2006). Each firm can use its own accumulated knowledge for production as well as making use of the knowledge stock accumulated in its economy and in the economy of its trading partner (in the case of the two-country model). The degree to which this knowledge is used would serve as a reflection of the strength of IPR protection in each particular country.

Consequently, the increase in IPR protection can be reflected as an increase in the production costs of the imitative sector, or as a decrease in the degree of the usage of the economy's accumulated knowledge by each particular firm.

As has been mentioned before, the focus of the current chapter is to model the relationship between IPR protection and economic growth in a developing country. However, the logical conclusion stemming from the discussion in the previous section implies the presence of significant discrepancies in the main characteristic between the economies of developed and less developed countries. Table 2.1 presents a summary of the characteristics of the industrialised economy that can be used to model a developing economy while constructing the model of endogenous technological change (the assumptions for the industrialised economy are adopted from Brecher, Choudhri, Schembri, 1996).

Table 2.1. Model assumptions: parameters of the economy

Closed economy	
Developed country	*Developing country*
Three-tier utility function: Industry level: Spence - Dixit – Stiglitz utility function Aggregate level: Cobb-Douglas production function Intertemporal level: logarithmic utility function	Three-tier utility function: Industry level: Spence - Dixit – Stiglitz utility function Aggregate level: Cobb-Douglas production function Intertemporal level: logarithmic utility function
Labour – the only factor of production	Labour – the only factor of production
Industry produces a set of differentiated varieties of a product under monopolistic competition.	Industry produces a set of differentiated varieties of a product under monopolistic competition.
Representative firm invests in knowledge creation and uses spillover stock of knowledge.	Representative firm does not invest in knowledge creation and uses free spillover stock of knowledge plus knowledge purchases from foreign companies.
A – level of technology that depends upon the excludable stock of knowledge of each firm that is defined by the *amount of its own R&D investments* and by the *spillover stock of knowledge* (that depends upon the knowledge spillover rate).	A – level of technology that depends upon the stock of knowledge of each firm that is defined by the *spillover stock of knowledge S* (that depends upon the knowledge spillover rate) and on the *amount of knowledge purchased abroad* (in a two-country framework).

2.6. Model: Autarky

The model is based on the work of Brecher *et al.* (1996) and is modified in order to focus on the role of the national IPR protection.

2.6.1. Supply

On the supply side, the industry consists of *n* firms that produce a set of differentiated varieties of a product under monopolistic competition in a closed economy. Continuous variety space is assumed, which represents the set of varieties produced at time *t* by the interval [$0,n(t)$].

Assumption 1 *Each firm investment in knowledge production is expressed by the function:*

$$R(t) = \int_0^t L_R(\tau)d\tau \tag{2.1}$$

where R represents the firm's accumulated investment in knowledge; L_R *is the number of labour force engaged in knowledge production (e.g. R&D).*

The industry starts operating at time $t=0$. According to the model's assumptions a representative firm manages to prevent only some part of its knowledge from spilling over to other firms in the industry at time *t* [7].

Assumption 2 *The firm's excludable stock of knowledge is defined as*

$$X(t) \equiv \int_0^t (1-z)e^{-\alpha(t-\tau)} L_R(\tau)d\tau \tag{2.2}$$

Where α *is the constant rate of knowledge spillover, and z is a new parameter representing piracy rate negatively related to the national level of IPR protection. The higher the rate of IPR protection in the country, the smaller is z, and the larger the excludable stock of knowledge for each firm in the industry.*

Then aggregate spillover stock of knowledge can be defined as

$$S = \tilde{R} - \tilde{X} \tag{2.3}$$

where tildes mean that a variable is an industry aggregate.

Each variety is produced using fixed (L_F) and variable (L_Y) amount of labour and takes place according to the following production function:

$$Y = AL_Y \tag{2.4}$$

in which L_Y is a variable amount of labour, A is the level of technology, determined by the firm's investment in technological knowledge and by spillover of knowledge produced by the rest of the industry (for simplicity spillovers from other industries are being ignored), and is defined as follows:

$$A \equiv f(X(t))e^{\beta S}, \beta > 0 \tag{2.5}$$

where $f'(X) < 0, f''(X) > 0, [f(X)]^{\sigma-1}$ *is concave*

The specification of technology ensures that, in spite of decreasing returns to each firm's own investment in knowledge, the aggregate results of such investments would lead to increasing returns to the spillover stock of knowledge [8]. Following Brecher *et al.* (1996), it should be noted that exponential relation between *A* and *S* ensures that, in the case of constant investment in knowledge, the rate of productivity growth would also be constant – a typical assumption in endogenous-growth models. In order to ensure the correspondence to the traditional empirical analysis of productivity growth, the model assumes that technological change takes the form of process improvements, i.e. shifts in the production function. However, model conditions could be modified to reflect the case in which investment in knowledge results in quality improvements[7].

2.6.2. Demand

According to the Spence-Dixit-Stiglitz utility function:

$$U_t = \int_t^\infty \frac{C_s^{1-\sigma}}{1-\sigma} e^{-\rho(s-t)} ds \tag{2.6}$$

demand for a variety *i* at time *t* is

$$D(i) = E[P(i)]^{-\sigma} / \int_0^n [P(j)]^{1-\sigma} dj \tag{2.7}$$

[7] In order to modify the model to reflect investment in quality improvements we would have to introduce a new parameter that would measure increasing product variety, with each product being produced with higher productivity due to better specialization.

where E[8] is the total expenditure on all varieties produced in the industry; *P(i)* is the price of a variety *i* at time *t*; $\sigma(>1)$ is the elasticity of substitution between any pair of varieties and also demand elasticity. In what follows, I omit time and variety arguments to simplify notation.

The assumption of Cobb-Douglas preferences at the aggregate level implies that industry expenditure constitutes a constant proportion of aggregate expenditure, which ensures the same growth rates for the sectoral and aggregate expenditures. Also, since the inter-temporal logarithmic utility function is assumed, the rate of growth of aggregate expenditure equals the difference between the rate of interest and subjective discount rate:

$$\dot{E}/E = \rho - \delta \tag{2.8}$$

where δ represents the discount rate ρ the rate of interest.

Firms have no impact on *E, S, W* (the wage rate), and each firm has to accept the paths of these variables over time as given.

A representative firm chooses the time paths of L_Y and L_R to maximize the discounted value of its profits over infinite horizon:

$$\pi = PY - W(L_F + L_Y + L_R) \tag{2.9}$$

Entering at $t=0$, each firm will maximize

$$V = \int_0^\infty e^{-\rho t}\pi(t)dt \tag{2.10}$$

subject to the following constraint implied by (2.2)[9]:

$$\dot{X} = (1-z)L_R - \alpha X \tag{2.11}$$

Free entry further implies that the present value of the profit of each firm at any given moment in time should be equal to the discounted value of its excludable knowledge, which implies that in the steady state, where *X(t)=X* (constant), it should equal zero. Otherwise, under the free entry assumption, positive/negative profits would imply

[8] See Appendix 2.13 for complete list of notations

[9] Refer to Appendix 2.10 for derivation.

further entrance/exit of firms into/from the sector until the zero profit condition is restored.

We can solve the model for unique values of X and n in steady-state equilibrium (refer to Appendix 2.11 for details):

$$X = \frac{(\alpha+\delta) + \sqrt{(\alpha+\delta)^2 + \frac{4(\alpha+\delta)(1-z)L_F}{(\sigma-1)}}}{\frac{2(\alpha+\delta)}{(\sigma-1)}} \tag{2.12}$$

$$\frac{\partial X}{\partial z} = -\frac{2L_F}{\sqrt{(\alpha+\delta)^2 + \frac{4(\alpha+\delta)(1-z)L_F}{(\sigma-1)}}} < 0 \tag{2.13}$$

$$n = \frac{E(1-z)}{\sigma W\left[X\left(\delta+\alpha\right) + L_F(1-z)\right]} \tag{2.14}$$

$$\frac{\partial n}{\partial z} = -\frac{E(\alpha+\delta)[X + \frac{\partial X}{\partial z}(1-z)]}{\sigma W\left(X(\alpha+\delta) + L_F(1-z)\right)^2} < 0 \tag{2.15}$$

Results implied by (2.13) and (2.15) show that any increase in the piracy rate z would eventually decrease the equilibrium excludable stock of knowledge for each firm, as well as the number of firms in the industry.

Now according to (2.1), (2.2), (2.3) and (2.11), and $\dot{X} = 0$, the growth rate of sector productivity can be found as follows:

$$\dot{S} = [\tilde{R} - \tilde{X}]'_t = \dot{\tilde{R}} - \dot{\tilde{X}} = nL_R - n(1-z)L_R + \alpha nX = n(zL_R + \alpha X) \tag{2.16}$$

$$\dot{S} = n(zL_R + \alpha X) \tag{2.17}$$

$$\dot{A} \equiv (f(X)e^{\beta s})'_t = f'(x)\dot{X}e^{\beta s} + \beta e^{\beta s}\dot{S}f(x) = \beta\dot{S}[\underbrace{f(x)e^{\beta S}}_{A}] = \beta\dot{S}A \tag{2.18}$$

$$\dot{A} / A = \beta n(zL_R + \alpha X) \tag{2.19}$$

In (2.19) the growth rate of sectoral productivity is expressed in terms of X (the excludable share of knowledge of a representative firm). However, as can be seen from (2.18), it can also be expressed in terms of a growth rate of the aggregate industry spillover stock of knowledge.

2.6.3. Analysis of the equilibrium

Steady state equilibrium is characterized by the set of values that depend on the parameters α, β, δ, $\sigma > 1$, $0 \le z \le 1$ and L_F:

$$X = \frac{(\alpha+\delta) + \sqrt{(\alpha+\delta)^2 + \frac{4(\alpha+\delta)(1-z)L_F}{(\sigma-1)}}}{\frac{2(\alpha+\delta)}{(\sigma-1)}} \tag{2.20}$$

$$n = \frac{E(1-z)}{\sigma W\left[X\left(\delta+\alpha\right) + L_F(1-z)\right]} \tag{2.21}$$

Using (2.11), (2.19), (2.20) and (2.21) we can calculate equilibrium values of the research and production labour force and the steady-state technology growth rate:

$$L_R = \frac{\alpha X}{(1-z)} \tag{2.22}$$

$$L_Y = \frac{E(\sigma-1)}{nW\sigma} \tag{2.23}$$

$$\frac{\dot{A}}{A} = \alpha\beta n X\left(\frac{z}{(1-z)} + 1\right) \tag{2.24}$$

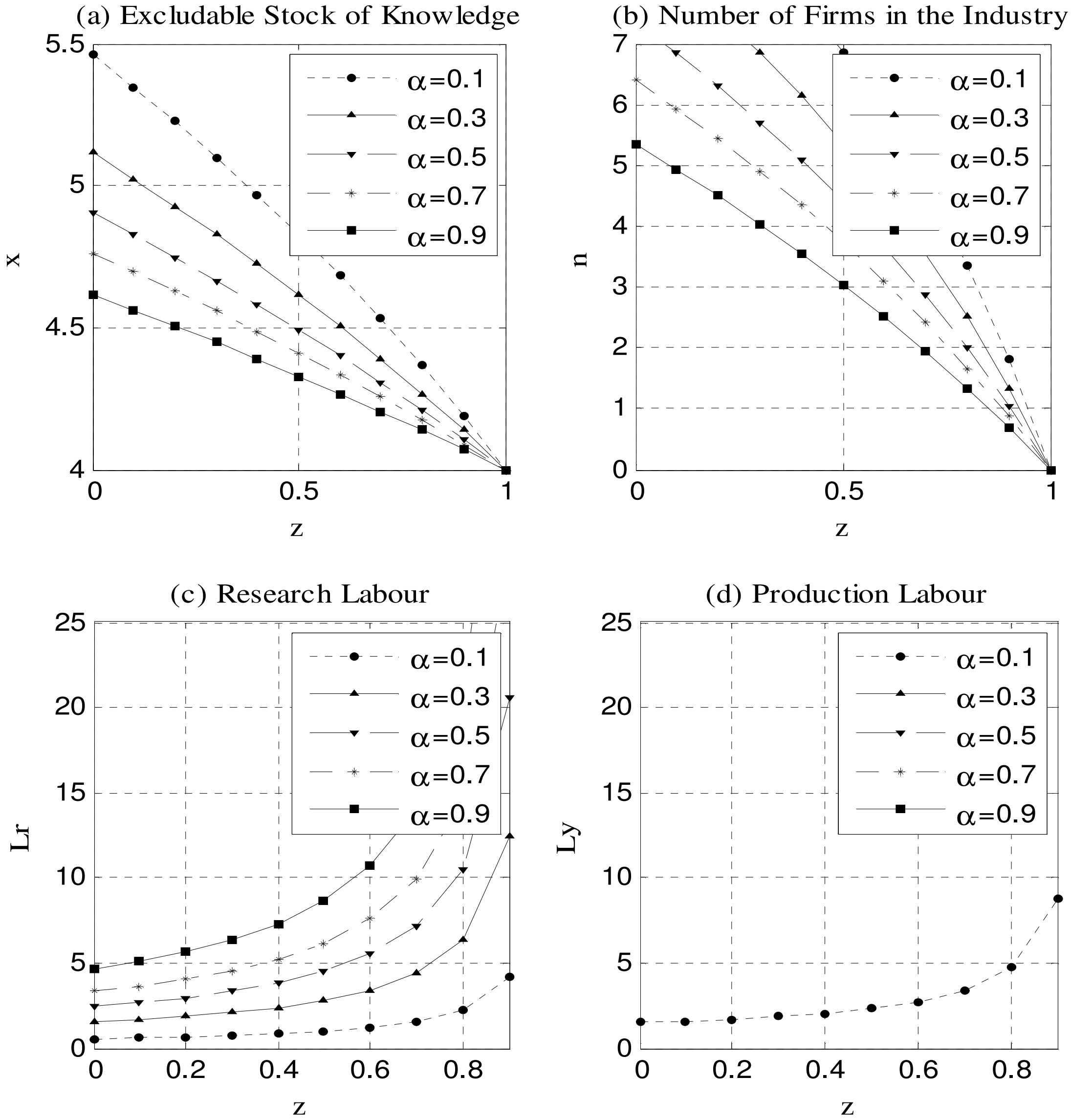
The remainder of this section implements a sensitivity analysis to study the impact of the national level of IPR protection (reflected in the piracy rate z), national knowledge spillover rate (α) and the rate of the spillover stock of knowledge accumulation (β) on the equilibrium model values. The two cases study the impact of piracy rate, which takes values $z \in [0,1]$, on the equilibrium model parameters for a range of values of parameters α (Case 1) and β (Case 2). Table 2.2 provides the set of parameter values used for simulations.

Table 2.2. Sensitivity Analysis Parameter Set: Autarky

Parameter	z	α	β	δ	σ
Restrictions				$0 < \delta <= 1$	$\sigma > 1$
Case 1	0:0.1:1	0.1:0.2:0.9	0.6	0.4	1.5
Case 2	0:0.1:1	0.3	0.6:0.4:2.2	0.4	1.5

Figure 2.1 illustrates the impact of changes in the piracy rate on the equilibrium values of the excludable stock of knowledge, labour engaged in production and R&D, and on the number of firms in the industry for a range of values of the national knowledge spillover rate (α).

Figure 2.1. Simulation results: Case 1[10]



Source: Own calculations

As we can see from the figure, an increase in the piracy rate results in a decline of the excludable stock of knowledge of each individual firm (panel (a)) and negatively affects the equilibrium number of firms in the sector (panel (b)). At the same time, higher

[10] The results of the simulations suggest that x tends to 4 as z tends to 1. This figure is a result of a parameter set chosen for simulations. In particular inclusion of $\alpha = 1$ in a set of the simulation parameters will give a value x=0 when z=0.

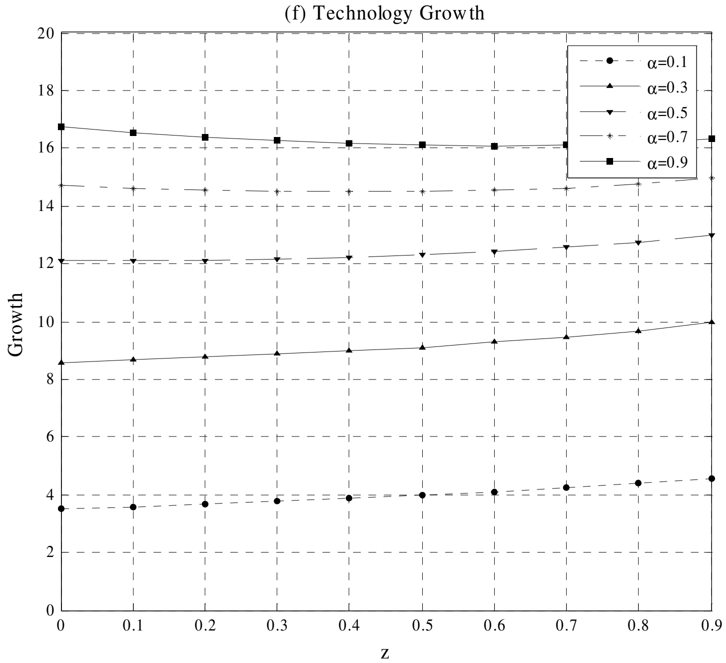
levels of piracy rate increase each firm's equilibrium amount of labour force engaged in R&D activities and in production process (panels (c) and (d)).

Interpretation of the simulation results suggests that, in case of poor IPR protection, incumbent firms have to increase their R&D expenditures in order to offset the negative impact of increasing knowledge loss, while those unable to raise their R&D investments are forced to exit the market. This in turn leads to a decline in a number of firms in the industry. A further increase in piracy rate results in a mass exit of firms from the sector, leaving it completely abandoned, when $z = 1$. At the same time, an increase in the amount of R&D investments during adjustment period by those firms that choose to stay in the sector positively affects sectoral productivity growth rate. Thus, during the process of adjustment, lower levels of IPR protection have a positive impact on the productivity growth rate. One has to bear in mind, however, that such a tendency will persist only until an overwhelming number of firms exit from the sector. Hence, in the long term, poor IPR protection will have an adverse effect on the productivity growth rate in the knowledge-producing industry.

Changes in the national knowledge spillover rate (α) do not exhibit any significant impact on the model parameters. Higher levels of α logically imply lower levels of the excludable stock of knowledge, lower number of firms in the industry and higher amount of research labour hired by a representative firm for knowledge creation (i. e. R&D activities). However, the nature of impact of the piracy rate z remains the same as described for all the range of simulation parameters α.

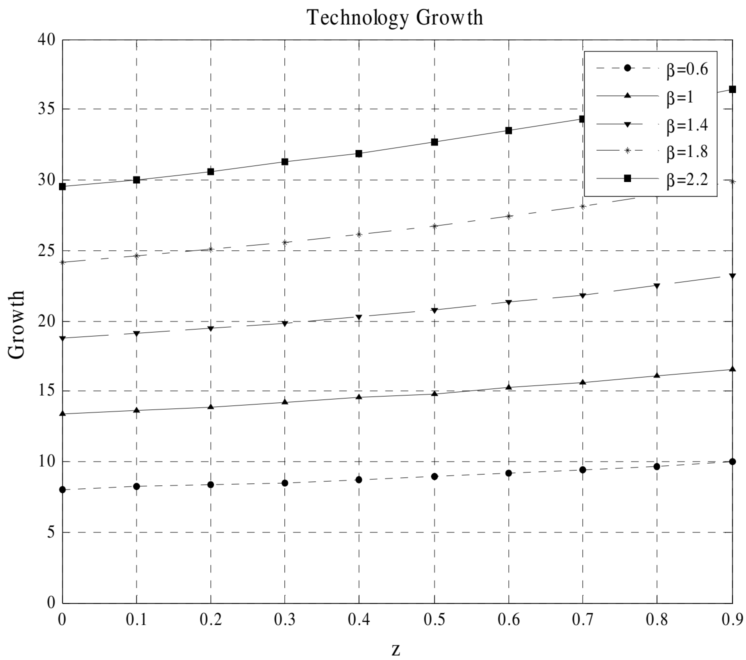
In case of sectoral productivity growth, the results are slightly different. Figure 2.2 plots the impact of piracy rate on the equilibrium sectoral productivity growth for a range of values of the national knowledge spillover rate α. As we can see, higher levels of α imply higher sectoral productivity growth rate. However, if the national knowledge spillover rate is close to 1 ($\alpha = 0.7$ and $\alpha = 0.9$), which implies that almost all the knowledge spills over to the rest of the industry, the impact of piracy rate on sectoral productivity growth rate becomes almost insignificant. Indeed, in a sector where the rate of knowledge spillover is already high, low levels of IPR protection would not add much to the aggregate spillover stock of knowledge, and consequently would not affect the dynamics of sector productivity growth.

Figure 2.2. Sectoral productivity growth: Case 1



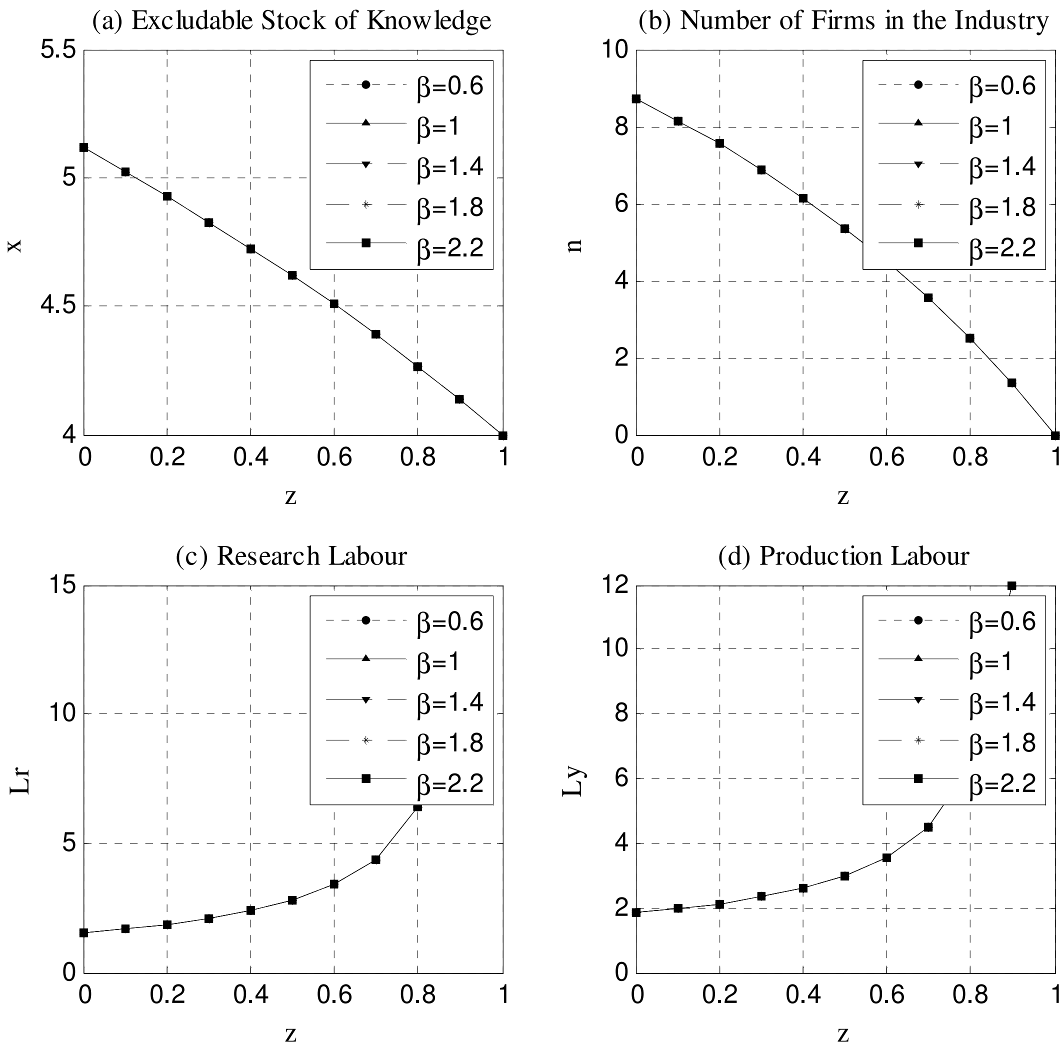
Source: Own calculations

Figure 2.3. Sectoral productivity growth: Case 2



Source: Own calculations

Figure 2.4. Simulation results: Case 2



Source: Own calculations

Figure 2.4 plots the impact of piracy rate on the equilibrium model values for a range of values of the parameter β. The results of the simulation show that β does not change the impact of the piracy rate on all the equilibrium model values except for the rate of sectoral productivity growth; in which case (Figure 2.3), higher values of β imply higher levels of sectoral productivity growth rate. However, the impact of piracy rate z on sectoral productivity growth remains positive for the whole range of β values.

The next section extends the model to a two-country framework, to explore how the results change in the presence of international trade.

2.7. Model: Open Economy

In the current section the model is modified in such a way that the country under consideration is a technology-consuming country, which produces no knowledge (further referred to as *home country*). Its technology is determined entirely by the amount of knowledge produced in the technology-producing country (further referred to as *foreign country*[11]) that spills over to the home country.

2.7.1. Supply

The main assumptions on the supply side remain the same as before. Industry consists of *n* firms that produce a set of differentiated varieties of a product under monopolistic competition. However, we now consider a model in a two-country setting. Again, continuous variety space is assumed; it represents the set of varieties produced at time *t* by the interval [*0,n(t)*].

Assumption 1 *Each firm in the foreign country invests in knowledge production according to the following function:*

$$R^*(t) = \int_0^t L^*_R(\tau)d\tau \qquad (2.25)$$

where R^* represents a firm's accumulated investment in knowledge; L^*_R is the number of labour force engaged in knowledge production (e. g. R&D).

The industry is assumed to start at time *t=0*. R^* represents foreign firm's accumulated investment in knowledge, and each foreign firm can prevent only some of this knowledge from spilling over to the *home country* firms at time *t*.

Assumption 2 *Following Brecher et al. [9], assume that rates of national and international knowledge spillover are the same. Then we can define the share of excludable stock of knowledge of the foreign country firm purchased by a home county firm as*

$$\xi^*(t) = (1-z)\int_0^t e^{-(\alpha/\phi)(t-\tau)} L^*_R(\tau)d\tau \qquad (2.26)$$

[11] Asterisks denote foreign country variables.

where α / ϕ is a constant rate of international knowledge spillover. Given $\phi > 1$, the speed of international knowledge spillover would be lower than the domestic one. This also means that $\alpha / \phi < \alpha$, although the spillover fraction of knowledge asymptotically approaches 1. Again, z is a parameter representing piracy rate negatively related to the level of IPR protection in the home country.

Following the analysis provided in Brecher *et al.* (1996) [9], we assume that a fraction of knowledge produced in the foreign country never spills over to the home country. Furthermore, since the home country does not produce any knowledge, its spillover stock of knowledge is now equal to a share of the spillover stock of knowledge produced in the foreign country. Thus, the amount of free knowledge available to each firm in the home country now becomes:

$$S = \varphi S^* = \varphi(R^* - \xi^*), 0 < \varphi < 1 \tag{2.27}$$

Each company in the home country decides to purchase some share of the excluded knowledge from a foreign country's firm, paying the price equal to the marginal revenue (W^*). The rest of the knowledge adds to the aggregate spillover knowledge stock and becomes available to all firms in the home country according to equation (2.27). Thus, the excludable stock of knowledge of the home country's representative firm is equal to a share of the excluded knowledge of the foreign country firm purchased by the home country firm:

$$X(t) = \xi^*(t) \tag{2.28}$$

Production of each variety in the home country requires fixed (L_F), and variable (L_Y) amount of labour, and takes place according to the following production function:

$$Y = AL_Y \tag{2.29}$$

in which L_Y is a variable amount of labour.

The level of technology (A) in the home country is determined by the amount of knowledge purchased by a representative home country firm from its foreign trading partner and by the home country spillover stock of knowledge S, and is defined as follows:

$$A \equiv f(\xi^*(t))e^{\beta S^*}, \beta > 0 \qquad (2.30)$$

where $f'(\xi^*) < 0, f''(\xi^*) > 0, [f(\xi^*)]^{\sigma-1}$ *is concave*

2.7.2. Demand

In a two-country setting, demand for a variety *i* at time *t* in the home country is:

$$D(i) = [P(i)^{-\sigma}[\frac{E}{\overline{P}} + \frac{E^*(T^*-1)^{-\sigma}}{\overline{P}^*}] \qquad (2.31)$$

where

$$\overline{P} \equiv \int_0^n [P(j)^{1-\sigma} dj + \int_0^{n^*} [P^*(j)(T-1)]^{1-\sigma} dj \qquad (2.32)$$

and

$$\overline{P}^* \equiv \int_0^n [P(j)(T^*-1)]^{1-\sigma} dj + \int_0^{n^*} [P^*(j)]^{1-\sigma} dj \qquad (2.33)$$

(T-1) and (T*-1) are the *ad valorem* tariffs on imports by the home and foreign countries. E and E^* represent the total expenditure on all home and foreign varieties produced in the industry; *P(i)* and $P^*(i)$ is the price of home and foreign variety *i* at time *t*; $\sigma(>1)$ is the elasticity of substitution between any pair of varieties as well as the elasticity of demand perceived by each firm. In what follows, I omit time and variety arguments whenever not needed for clarity.

Assuming Cobb-Douglas preferences at the aggregate level, industry expenditure constitutes a constant proportion of aggregate expenditure, which ensures the same growth rates for the sectoral and aggregate expenditures. Also, since the inter-temporal logarithmic utility function is assumed, the rate of growth of aggregate expenditure equals the difference between the rate of interest and subjective discount rate:

$$\frac{\dot{E}}{E} = \rho - \delta \qquad (2.34)$$

A firm chooses the time path of L_Y to maximize the discounted value of its profits over infinite horizon. At the same time it chooses the optimal share of the excludable knowledge of the foreign firm to purchase. In this case the discounted value of the home country profits will be given by:

$$\pi = PY - W(L_F + L_Y) - W^* L_R^* \tag{2.35}$$

Entering at $t = 0$ the firm will maximize

$$V = \int_0^\infty e^{-\rho t} \pi(t) dt \tag{2.36}$$

subject to the constraint implied by (2.26)[12]:

$$\dot{\xi}^* = L_R^*(t)(1 - z) - \frac{\alpha}{\varphi} \xi^* \tag{2.37}$$

Under the condition of free entry, the present value of the profit of each firm in the home country at any given moment of time should be equal to the discounted value of its excludable knowledge. Thus in the steady state, where $\xi^*(t) = \xi^*$ (constant), it should equal zero.

This allows solving the model for unique values of ξ^* and n in steady-state equilibrium:

$$n = \frac{\left(\frac{\alpha}{\phi} + \delta\right) W^* \sigma}{(1 - z)(\sigma - 1)\bar{E}\xi^*} \tag{2.38}$$

$$\frac{\partial n}{\partial z} = \frac{\left(\frac{\alpha}{\phi} + \delta\right) W^* \sigma(\sigma - 1)\bar{E}\xi^*}{\left((1 - z)(\sigma - 1)\bar{E}\xi^*\right)^2} > 0 \tag{2.39}$$

$$\xi^* = \frac{\left(W^*\left(\frac{\alpha}{\phi} + 1\right) + \sqrt{\left(W^*\left(\frac{\alpha}{\phi} + 1\right)\right)^2 + \frac{4L_F W W^*\left(\frac{\alpha}{\phi} + \delta\right)}{(1 - z)(\sigma - 1)}} \right) * (\sigma - 1)}{W^*\left(\frac{\alpha}{\phi} + \delta\right)\bar{E}} \tag{2.40}$$

[12] Refer to Appendix 2.10 for details.

$$\frac{\partial \xi}{\partial z}=\frac{2L_F W}{E(1-z)^2(\sigma-1)\sqrt{\left(W^*\left(\frac{\alpha}{\phi}+1\right)\right)^2+\frac{4L_F WW^*\left(\frac{\alpha}{\phi}+\delta\right)}{(1-z)(\sigma-1)}}}>0 \quad (2.41)$$

The results implied by (2.39) and (2.41) show that any increase in the piracy rate z would eventually increase the number of firms in the industry, as well as the equilibrium share of the foreign excludable stock of knowledge purchased by a representative home-country firm.

According to (2.25)-(2.28) and (2.30)-(2.37), with $\dot{\xi}^*=0$, the growth rate of sectoral productivity can be expressed as:

$$\dot{S}^*=\varphi\dot{S}=\varphi[\tilde{R}^*-\tilde{\xi}^*]'_t=\varphi\left(nL_R-n\left((1-z)L_R^*+\frac{\alpha}{\varphi}\xi^*\right)\right)=\varphi n(zL_R^*+\frac{\alpha}{\varphi}\xi^*) \quad (2.42)$$

$$\dot{S}=\varphi n(zL_R^*+\frac{\alpha}{\varphi}\xi^*) \quad (2.43)$$

$$\dot{A}\equiv(f(\xi^*)e^{\beta s})'_t=f'(\xi^*)\dot{\xi}^*e^{\beta s}+\beta e^{\beta s}\dot{S}f(\xi^*)=\beta\dot{S}[\underbrace{f(\xi^*)e^{\beta S}}_{A}]=\beta\dot{S}A \quad (2.44)$$

$$\frac{\dot{A}}{A}=\beta\dot{S}=\beta\varphi n(zL_R^*+\frac{\alpha}{\varphi}\xi^*) \quad (2.45)$$

(2.43) is expressed in terms of ξ^* - the share of foreign excludable knowledge purchased by a representative firm in the home country.

In the current version of the model, we have explored a two-country framework with a flow of knowledge between a technology-producing country and a technology-consuming country. The results of the model imply that the growth rate of technology in the home country depends entirely on the amount of technology produced in the foreign country, and an increase in the piracy rate associated with lower rates of IPR protection in the home country would have a positive effect on its sector productivity growth rate. A closer look at the equation (2.45) shows that sector productivity growth in the home country depends on the excludable stock of knowledge and R&D labour force of the foreign country. According to the model assumptions, the home country's IPR protection level has no impact on the foreign country equilibrium variables. Hence, the increase in the home country piracy rate would result in an increase in its sector productivity growth rate.

These findings imply that, in the case of less developed countries that do not have sufficient capacity to produce technology of international standards, and have to make use of foreign technologies, the stronger IPR protection required by the TRIPS agreement may have an adverse effect on sectoral productivity growth rate and, as a consequence, may hinder the economic development of such countries.

2.7.3. Analysis of the equilibrium

Steady state equilibrium is characterized by the set of values that depend on the parameters α, β, δ, $\sigma > 1$, $\varphi < 1$, $0 \le z \le 1$ and L_F :

$$\xi^* = \frac{\left(W^*\left(\frac{\alpha}{\phi}+1\right) + \sqrt{\left(W^*\left(\frac{\alpha}{\phi}+1\right)\right)^2 + \frac{4L_F WW^*\left(\frac{\alpha}{\phi}+\delta\right)}{(1-z)(\sigma-1)}} \right) * (\sigma-1)}{W^*\left(\frac{\alpha}{\phi}+\delta\right)\bar{E}} \qquad (2.46)$$

$$n = \frac{\left(\frac{\alpha}{\phi}+\delta\right)W^*\sigma}{(1-z)(\sigma-1)\bar{E}\xi^*} \qquad (2.47)$$

Using (2.11), (2.19), (2.20) and (2.21), we can calculate a set of the home country equilibrium values of the research and production labour force and steady-state technology growth rate:

$$L_Y = \frac{E(\sigma-1)}{nW\sigma} \qquad (2.48)$$

$$\frac{\dot{A}}{A} = \beta\varphi n\left(zL_R^* + \frac{\alpha}{\phi}\xi^* \right) \qquad (2.49)$$

The rest of this section implements a sensitivity analysis, which makes it possible to explore the response of the equilibrium model parameters to the changes in the national level of IPR protection reflected in the piracy rate, international knowledge spillover rate (α / ϕ) and the rate of the knowledge spillover stock accumulation (β). The two cases study the impact of piracy rate, which takes values $z \in [0,1]$, on the equilibrium model parameters for a range of values of parameters α / ϕ (Case 1) and β (Case 2). Table 2.3 provides a set of parameter values used for simulations.

Table 2.3. Sensitivity Analysis Parameter Set: Open economy

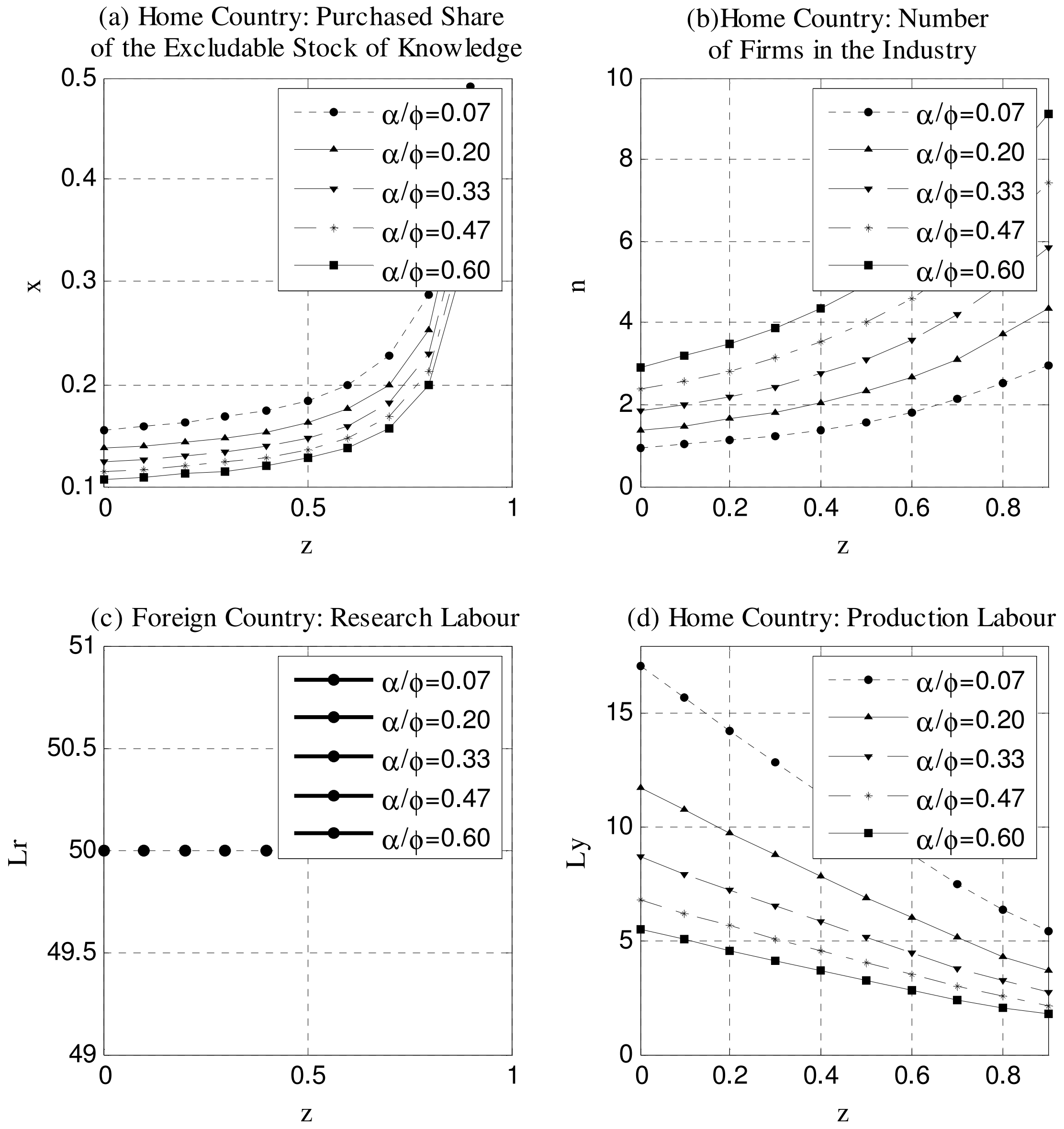
Parameter	z	α	ϕ	β	δ	σ
Restrictions					$0 < \delta <= 1$	$\sigma > 1$
Case 1	0:0.1:1	0.1:0.2:0.9	1.5	0.6	0.4	1.5
Case 2	0:0.1:1	0.3	1.5	0.6:0.4:2.2	0.4	1.5

Figure 2.5 illustrates the impact of changes in the piracy rate $z \in [0,1]$ for a range of values of the international knowledge spillover rate (α / ϕ) on such equilibrium model parameters as share of the foreign excludable stock of knowledge purchased by a representative home-country firm, value of labour engaged in production and number of firms in the industry

As we can see from the figure, an increase in piracy rate results in an increase of the share of the excludable stock of knowledge purchased by a representative home-country firm (panel (a)). At the same time, higher levels of piracy rate increase the equilibrium number of firms in the sector (panel (b)) and decrease each firm's equilibrium amount of labour engaged in production (panel (d)). This means that higher levels of piracy rate lead to a larger number of firms in the industry, with each firm producing a smaller share of the total output.

Changes in the international knowledge spillover rate do not lead to any significant changes in model dynamics. An increase in the international knowledge spillover rate ($\alpha / \phi \uparrow$) magnifies the impact of piracy rate on the equilibrium model values. In particular, an increase in α / ϕ leads to higher levels of the purchased share of the excludable stock of knowledge and attracts more firms to the industry. However, the impact of piracy rate z on sectoral productivity growth remains positive for the whole range of simulation parameters. Moreover, in the case of a technology-consuming country, high levels of α / ϕ magnify the impact of piracy rate on the home country sectoral productivity growth (Figure 2.6). Also, since higher z also increases equilibrium number of firms in the industry, the positive impact of piracy rate on sectoral productivity growth in a technology-consuming country can be sustained in the long term.

Figure 2.5. Simulation Results: Case 1

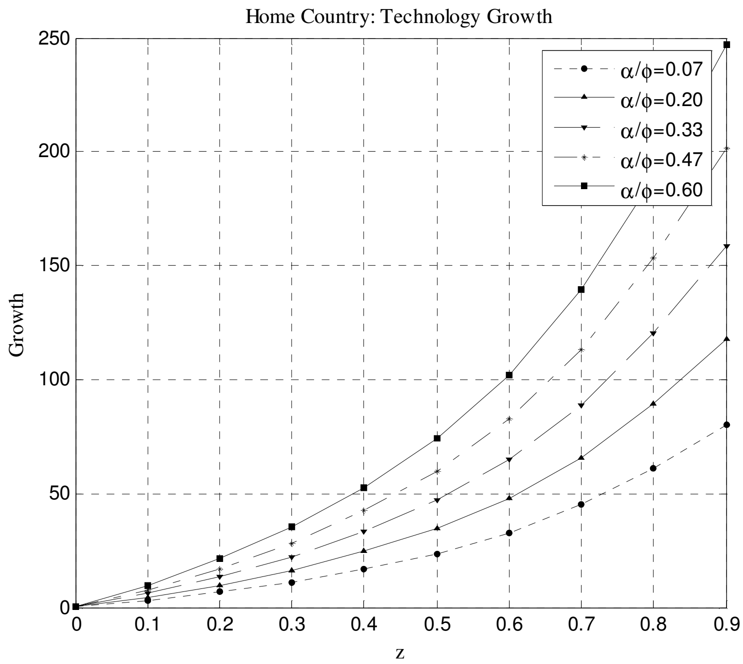


Source: Own calculations

Figure 2.8 plots the impact of piracy rate $z \in [0,1]$ on the equilibrium model values for a range of values of parameter β. The results of the simulation show that β does not change equilibrium model parameters and does not affect the impact of piracy rate on all the equilibrium model values, except for the sectoral productivity growth, in which case (Figure 2.7), higher values of β imply higher levels of sectoral productivity growth. However, the impact of piracy rate z on sectoral productivity growth remains positive for the whole range of β values.

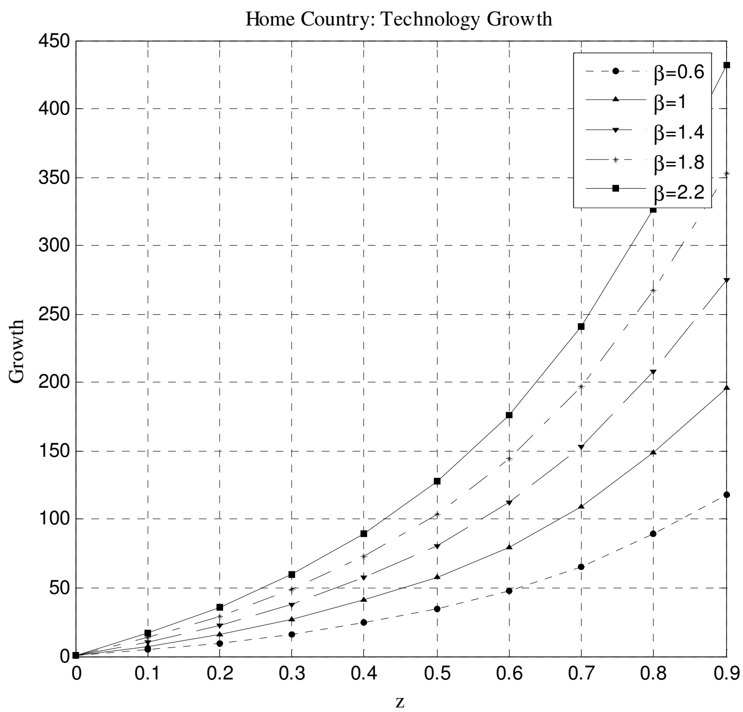
The main conclusion of the two-country framework is that for a technology-consuming country, high levels of national IPR protection may have an adverse affect of sectoral productivity growth.

Figure 2.6. Home Country Productivity Growth: Case 1



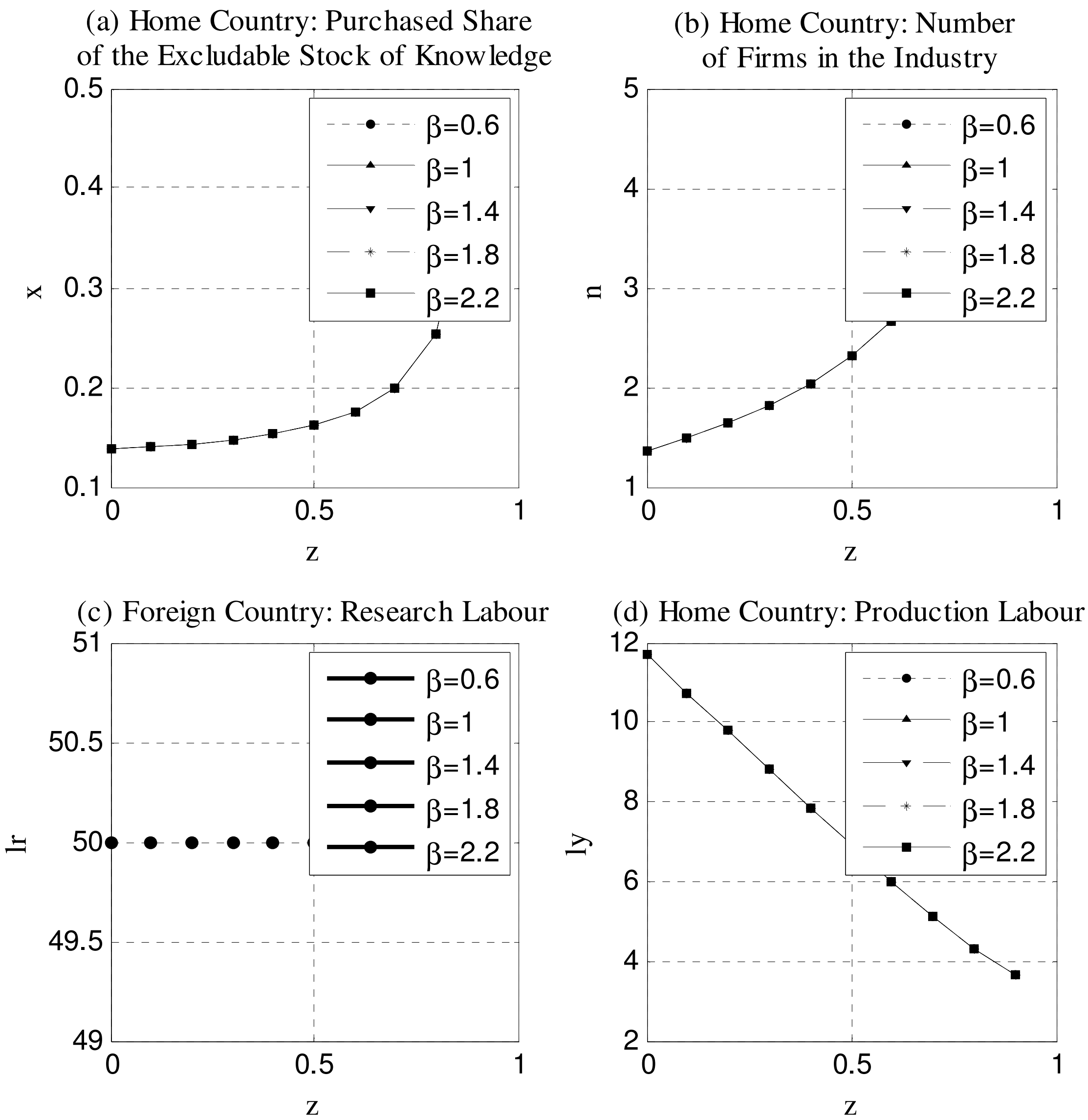
Source: Own calculations

Figure 2.7 Home Country Productivity growth: Case 2.



Source: own calculations

Figure 2.8. Simulation Results: Case 2



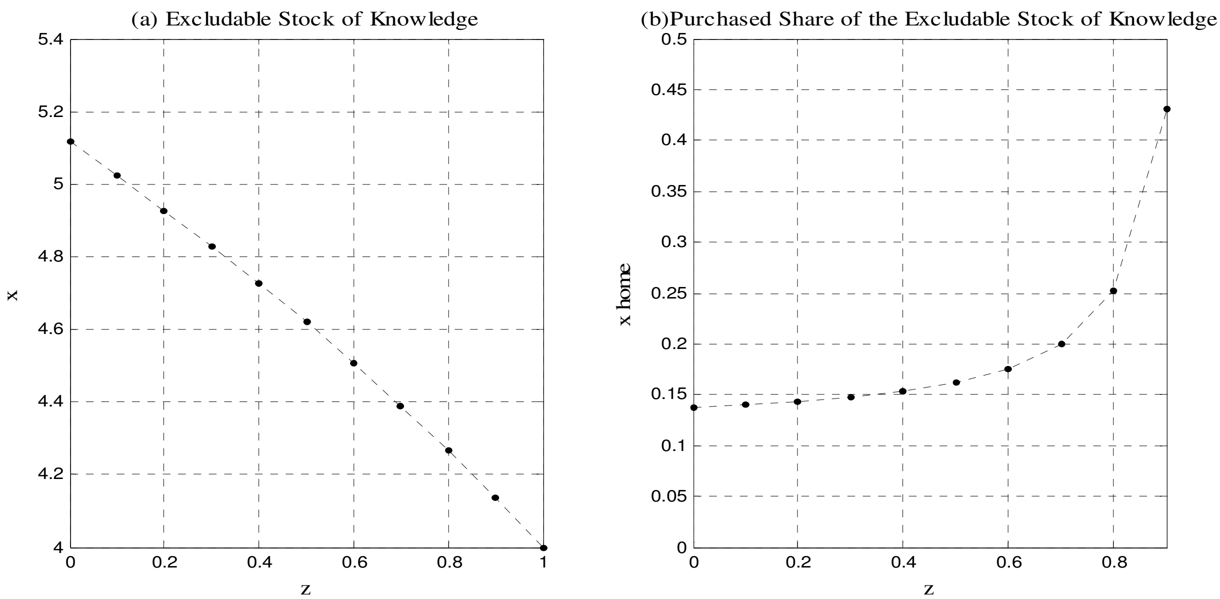
Source: Own calculations

2.8. Comparative Statics Analysis

This section aims to provide some additional analysis of the equilibrium conditions arising in the two versions of the model.

Figure 2.9 compares equilibrium values of the excludable stock of knowledge in a closed country framework (panel (a)) and in a two-country framework (panel (b)) for values of the piracy rate $z \in [0,1]$. As we can see from the figure in the case of a knowledge-producing country, an increase in piracy rate z negatively affects the stock of knowledge each firm is able to exclude from spilling over to other firms in the industry. However, in a two-country framework, an increase in piracy rate z positively affects the equilibrium amount of foreign knowledge purchased by a representative home-country firm.

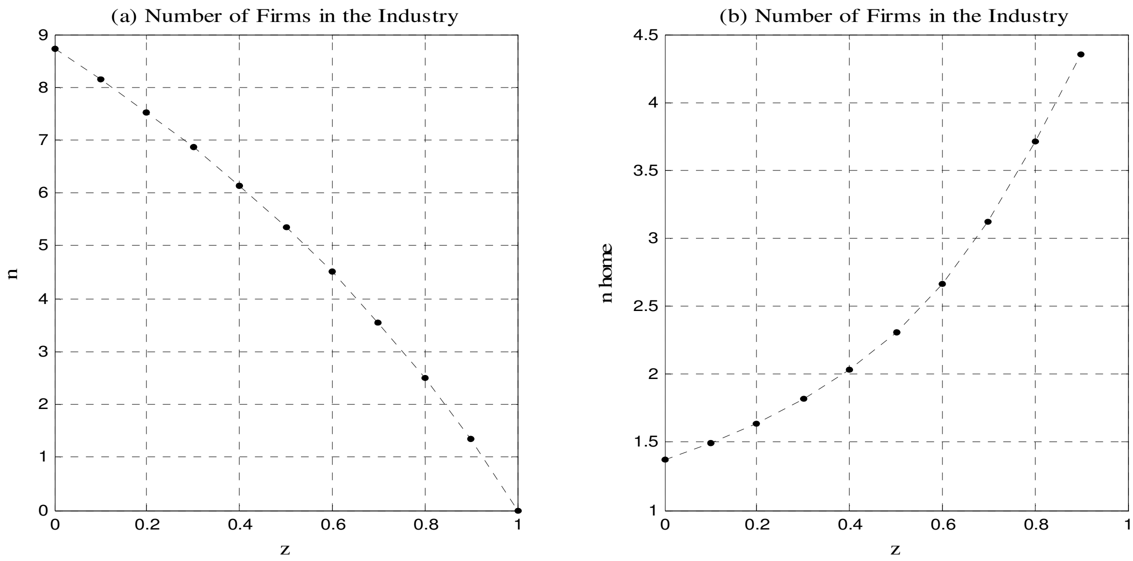
Figure 2.9. Comparison of equilibrium values: Excludable stock of knowledge



Source: Own calculations

Figure 2.10 plots the equilibrium values of a number of firms in the industry in a closed country framework (panel (a)) and in a two-country framework (panel (b)) for values of the piracy rate $z \in [0,1]$. Again, in the first version of the model, where a country is a knowledge producer, an increase in piracy rate negatively affects the equilibrium number of firms in the industry. Also, in the extreme case, when $z = 1$, which makes exclusion of any knowledge from spilling over to other firms in the industry impossible, all firms choose to cease their activity and exit the market. However, in a two country framework (panel (b)), an increase in the piracy rate positively affects the equilibrium number of firms in the home-country industry. The logic implies that, in the latter case, a higher piracy rate attracts more firms to the industry owing to higher levels of free aggregate spillover stock of knowledge (S).

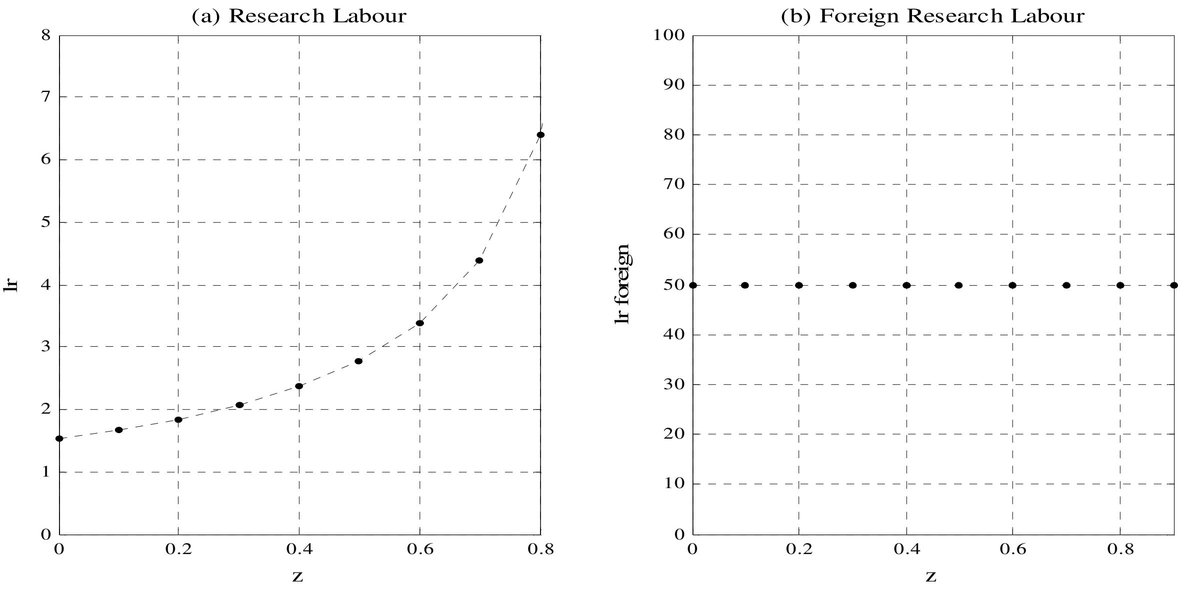
Figure 2.10. Comparison of equilibrium values: Number of firms in the industry



Source: Own calculations

Figure 2.11 plots the equilibrium value of the research labour force employed by a representative firm in the industry in a closed country framework (panel (a)), and equilibrium value of the research labour force employed by a representative firm in the foreign country in a two-country framework (panel (b)) for values of the piracy rate $z \in [0,1]$. In the first version of the model (panel (a)), an increase in piracy rate z increases the equilibrium amount of research labour employed by a representative firm in the industry. Logically, firms have to increase their investment in R&D, expressed via the increase in the number of employees engaged in R&D activities, in order to offset the negative impact of increasing knowledge loss (caused by the increase in z). In the two-country framework, the home country produces no knowledge; thus its research labour force equals zero. Also, according to the model assumptions, an increase in the home country piracy rate z has no effect on the equilibrium number of research labour in the foreign-country industry (panel (b)).

Figure 2.11. Comparison of equilibrium values: Research labour

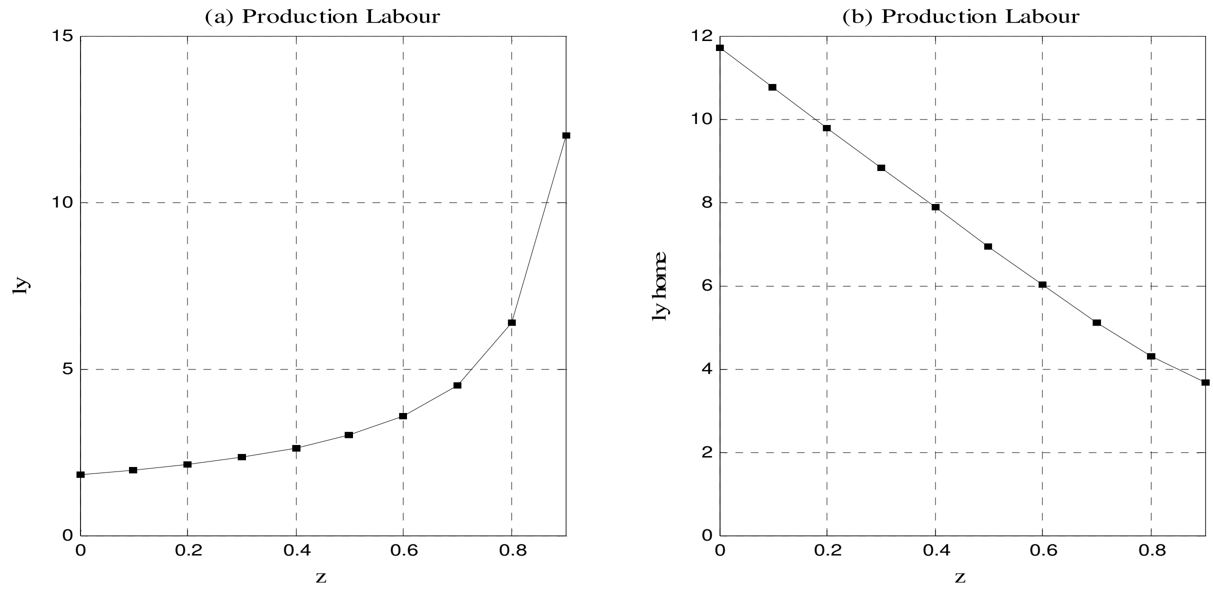


Source: Own calculations

Figure 2.12 plots the equilibrium value of the production labour force employed by a representative firm in the industry in a closed country framework (panel (a)) and a two-country framework (panel (b)) for the values of piracy rate $z \in [0,1]$. In a closed country framework, an increase in piracy rate leads to an increase in the equilibrium amount of production labour employed by a representative firm in the industry. Looking back at Figure 2.11, one can notice that, in a closed-country framework, an increase in piracy rate has a positive impact on both research and production labour values. Such results might imply that higher levels of piracy rate force small firms to cease production and exit the market, while bigger firms are still trying to offset the negative impact of z by increasing their investment in R&D activities and expanding production. However, a further increase in the piracy rate results in a mass exit of firms from the sector, leaving the sector completely abandoned, when $z = 1$ (Figure 2.10 (a)).

As discussed before, in a two-country framework, an increase in piracy rate z results in an increase of the equilibrium number of firms in the home-country industry (Figure 2.10 (b)). This logically implies that each firm would be producing a smaller share of industry output and would employ less labour for production purposes, which is reflected in panel (b) of Figure 2.12 below.

Figure 2.12. Comparison of equilibrium values: Production labour



Source: Own calculations

Finally, Figure 2.13 plots the equilibrium values of sectoral productivity growth in a closed country framework (panel (a)) and in a two-country framework (panel (b)) for a range of piracy rate values $z \in [0,1]$. As we can see from the figure, an increase in piracy rate raises the equilibrium productivity growth rate in a knowledge-producing country (closed country framework, panel (a)) as well as in a knowledge-consuming country (two-country framework, panel (b)).

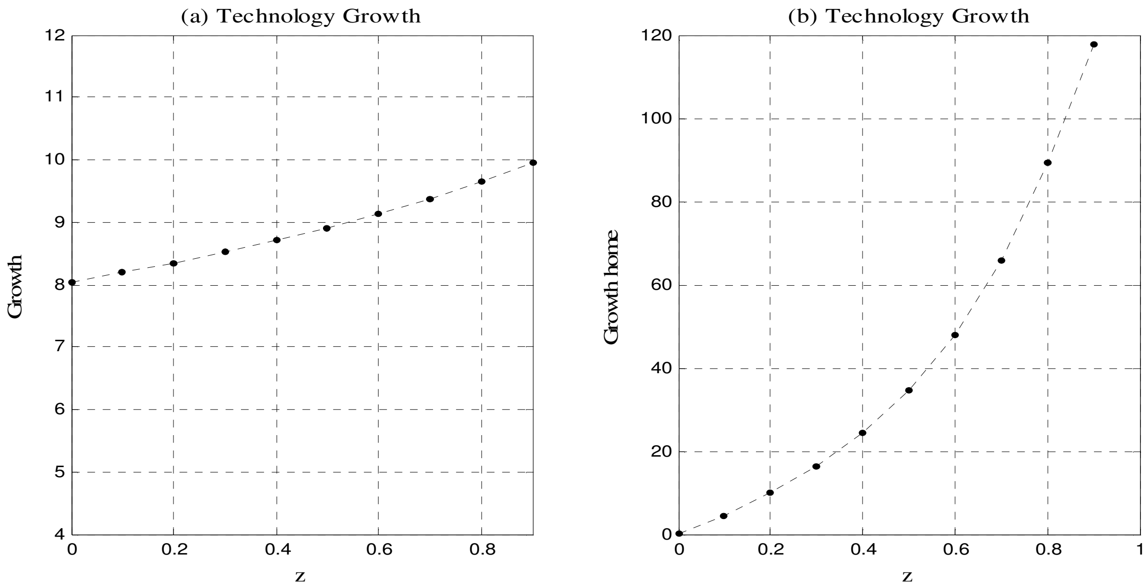
One has to bear in mind, however, that the impact of piracy rate on the industry structure is different in the two frameworks. In particular, in a knowledge-producing country, high levels of piracy rate might lead to a mass exit of firms from the market, thus leaving the sector completely abandoned, when $z = 1$. Hence, the positive impact of z on sector productivity growth reflected in panel (a) of Figure 2.13 is not sustainable in the long term. In the two-country framework, the situation is different. Higher levels of z make the sector more attractive because of the higher levels of the free aggregate spillover stock of knowledge, which attracts more firms to enter the industry. Such a tendency implies that, in the case of a technology-consuming country, low levels of IPR protection result in higher sector productivity growth, which can be sustained in the long term. The main channel through which low IPR protection affects productivity growth is increased technology transfer from abroad, which is the only source of productivity growth for a technology-consuming country.

Several studies have confirmed the importance of technology transfer as a source of productivity growth. In one of their recent papers, Choudri and Hakura (2000) pointed out that the effect of increased trade openness on productivity growth depends on the growth potential of the sector [10]. In this case, an increase in international trade would have no significant effect on productivity growth rate of labour-intensive (low-growth) sectors, while in capital-intensive sectors with high growth potential, an increase in international trade would have a significant growth-enhancing effect via increased technology transfer and import competition.

Applying the findings of Choudri and Hakura (2000) to the results of the current analysis allows us to conclude that increased trade openness and low levels of IPR protection affect productivity growth in the same way, i.e. by increasing technology transfer. Both low IPR protection and increased trade flows increase the amount of technologies available to local producers, thus raising sectoral productivity growth. In the case of a technology-producing country, low IPR might have a destructive effect on the industry structure in the long term, creating an inhospitable environment for technology-producing firms. However, the *home country industry* presented in section 2.7 of this chapter does not produce any technology, and at the same time it can be characterised as a medium- or high-growth sector, as it makes use of foreign technologies for imitative purposes. Thus, according to the findings of Choudri and Hakura (2000), increased trade openness as well as low IPR protection would positively affect productivity growth of such industry via an increase in technology transfer from abroad.

This conclusion is supported by a number of stylized facts on developing countries. Countries such as Mexico, Brazil, China, India, Vietnam, Indonesia, although officially committed to meet the requirements of the TRIPS agreement, are consistently blamed for unsatisfactory patent protection. The current findings justify the persistence of developing countries, whose economies depend to high extend on imitative sectors, to support technology piracy as a means to increase sectoral - and as a result - aggregate productivity growth.

Figure 2.13. Comparison of equilibrium values: Technology growth



Source: Own calculations

2.9. Summary

The theoretical analysis presented in the current chapter adjusts the sectoral model of endogenous growth developed by Brecher, Choudrhri and Schembri (1996) to a setting in which the country under study does not produce any new technologies from its own sources. Instead, a representative firm uses technologies from abroad acquired through knowledge purchases and knowledge spillovers. In practice, the former is usually done through licence purchasing and through the use of imported intermediate inputs and equipment. The latter includes reverse engineering, imitation and adjustment of technologies, production methods and managerial practices from other domestic and foreign firms.

The first version of the model considers a knowledge-producing industry in autarky. This model assumes that the amount of knowledge the firm is able to exclude from spilling over to other firms in the industry is negatively related to *piracy rate.* Piracy rate is a new term which is introduced as an addition to the previous version of the model developed by Brecher et al. (1996) in order to reflect the strength of the IPR protection in the economy and distinguish between varying levels of IPR protection present in many developing and emerging countries.

The results of the analysis suggest that higher levels of piracy rate are associated with higher levels of sectoral productivity growth rate. However, since the industry is populated with knowledge-producing firms, high levels of piracy rate would lead to the mass exit of firms from the market, leaving the sector completely abandoned, when $z = 1$. Owing to this adverse effect of the piracy rate on the industry structure, the positive impact of z on sector productivity growth reflected in panel (a) of Figure 2.13 is not sustainable in the long term.

The theoretical analysis is further extended to a two-country framework in which the *home country* produces no knowledge and depends entirely on the knowledge produced in the *foreign country*, acquiring it through legal purchases and knowledge spillovers. In this case, the results of the analysis indicate that the high levels of piracy rate associated with low levels of IPR protection are beneficial for a technology-consuming country. Moreover, higher levels of z make the home-country's industry more attractive, owing to higher levels of the free aggregate spillover stock of knowledge. This in turn results in a mass entry of new firms into the industry. Such a result implies that, in a knowledge-consuming country, low levels of IPR protection would result in a higher level of sector productivity growth which can be sustained in the long term.

The results of the analysis shed some light on the reasons behind the policies of some developing countries aimed at deliberate under-protection of Intellectual Property Rights, and their failure to implement the level of IPR protection required by international authorities. Overall, the findings of the current chapter have important implications for the formation of the long-term industrial policies. Although, low IPR standards might seem appealing for the countries with high share of imitative sectors in the economy, the consequences of persistent under protection of IPR might include a number of economic sanctions from the side of international trade regulating bodies such as WTO, as well as from developed trade partners. Thus, in order to sustain productivity growth in the long run developing and emerging economies (Ukraine being one of them) should concentrate on the development of government programs that would stimulate domestic research and upgrade firms' innovative capabilities. Such policy strategy will have a double positive effect on the economy. Under such policies an increase in productivity growth coming from domestic innovation would be magnified by the effects coming from increasing share of exporters and enhanced import competition.

There are several possible extensions to the current version of the model. First, it is logical that the international knowledge spillover rate depends on the country's openness to international trade and investment. This assumption can also be incorporated into the model by making the rate of international knowledge spillover an increasing function of some kind of index of trade openness, with the index of Trade Freedom provided by the Heritage Foundation and Wall Street Journal used as a proxy. Alternatively, the index can be derived by comparing the export intensity of the manufacturing and service sectors, and the number of FDI in different countries. It would also be interesting to study the impact of IPR protection on the productivity growth of individual sectors. However, such an exercise would require productivity data which for most developing countries are available only at the aggregate level. Moreover, the index of IPR protection developed by Ginarte and Park (1997) is available on the aggregate level and for 5 year intervals only. Finally, the model can also be modified to include several factors of production. However, such an extension - while adding to the complexity of the model - would not change the results of the current analysis.

2.10. Appendix. Excludable knowledge dynamics

Since the firm's excludable stock of knowledge is defined as

$$X(t) \equiv \int_0^t (1-z)e^{-\alpha(t-\tau)} L_R(\tau) d\tau \tag{2.50}$$

We can derive excludable knowledge growth rate as follows:

$$X(t) = \underbrace{(1-z)e^{-\alpha t}}_{u(t)} \underbrace{\int_0^t e^{\alpha\tau} L_R(\tau) d\tau}_{\upsilon(t)}$$

$$\dot{X} = \dot{u}\upsilon + u\dot{\upsilon}$$

$$\dot{u} = -(1-z)\alpha e^{-\alpha t}$$

$$\dot{\upsilon} = (\int_0^t e^{\alpha\tau} L_R(\tau) d\tau)'_t = e^{\alpha t} L_R(t)$$

$$\dot{X} = (1-z)L_R - \alpha X$$

The same strategy is applied in the two-country framework to derive equation (2.37). It should be noted that, despite the fact that home country depends entirely on the technologies generated abroad, piracy rate z enters equation (2.26) in a similar way it enters equation (2.2). This occurs owing to the model assumption that implies that the level of IPR protection in the foreign country is already sufficiently high to preclude any additional knowledge spillovers.

2.11. Appendix. Profit Maximization: Autarky

If we assume that a representative firm chooses the time paths of L_Y and L_R to maximize over infinite horizon, the discounted value of its profits is given by:

$$\pi = PY - W(L_F + L_Y + L_R) \qquad (2.51)$$

and can be represented as:

$$\pi = \frac{E[(\sigma W)/(\sigma - 1)e^{\beta S}]^{1-\sigma}}{\sigma \int_0^n p_j^{1-\sigma} dj} f(X)^{\sigma-1} - W(L_F + L_R)$$

$$C = \frac{E[(\sigma W)/(\sigma - 1)e^{\beta S}]^{1-\sigma}}{\sigma \int_0^n p_j^{1-\sigma} dj};$$

$$\pi = Cf(X)^{\sigma-1} - W(L_F + L_R) \qquad (2.52)$$

The firm entering at time zero will maximize

$$V = \int_0^\infty e^{-\rho t} \pi(t) dt \qquad (2.53)$$

subject to the following constraint implied by (2.2):

$$\dot{X} = (1 - z)L_R - \alpha X \qquad (2.54)$$

$$H = C[f(X)^{\sigma-1} - W(L_R + L_F) + \lambda((1 - z)L_R - \alpha X) \qquad (2.55)$$

The first order conditions for a maximum are obtained imposing:

$$\frac{\partial H}{\partial X} = -\dot{\lambda} + \rho\lambda \qquad (2.56)$$

$$\frac{\partial H}{\partial L_R} = 0 \qquad (2.57)$$

$$\lim_{t \to \infty} \lambda(t) X(t) = 0 \qquad (2.58)$$

According to Mangasarian (1966), since $v(\cdot) = \pi(\cdot)$ and $g(\cdot) = \dot{X}(\cdot)$ are both concave in X and L_R, then the necessary conditions are also sufficient [11]:

$$\begin{gathered}
\nu(L_R, X) = Cf(X)^{\sigma-1} - W(L_F + L_R) \\
\frac{\partial \nu}{\partial X} = C(\sigma-1) f(X)^{\sigma-1} \frac{f'(X)}{f(X)} \\
\frac{\partial \nu}{\partial L_R} = -W
\end{gathered} \tag{2.59}$$

Since $[f(X)]^{\sigma-1}$ is concave according to the assumptions of the model and $\frac{f'(X)}{f(X)}$ is constant, then equations (2.59) imply that $\nu(\cdot) = \pi(\cdot)$ is concave in both X and L_R.

$$\begin{gathered}
g(X, L_R) = (1-z)L_R - \alpha X \\
\frac{\partial g}{\partial X} = -\alpha \\
\frac{\partial g}{\partial L_R} = (1-z)
\end{gathered} \tag{2.60}$$

Since $g(\cdot) = \dot{X}(\cdot)$ is a linear function of X and L_R it is both concave and convex in X and L_R by definition.

Steady state solution

Using equations(2.8), (2.11), and the results of the profit maximization (2.56) and (2.57) we find:

$$\frac{f'(X)}{f(X)} = \frac{n((\alpha+\delta))W\sigma}{E(\sigma-1)(1-z)} \tag{2.61}$$

In the steady state where *X(t)=X* (constant), the profit of each firm at any given point in time equals the discounted value of its excludable knowledge:

$$\int_t^{\infty} e^{-\rho t} \pi(t) dt = \lambda(t) X \tag{2.62}$$

where λ - shadow price of X

$$\dot{X} = (1-z)L_R - \alpha X = 0 \tag{2.63}$$

$$\frac{\dot{W}}{W} = \frac{\dot{E}}{E} = \rho - \delta \tag{2.64}$$

Now use (2.8), (2.11), (2.52), (2.57), (2.62) to get:

$$\frac{(\alpha+\beta)}{(1-z)}X = \frac{E}{n\sigma W} - L_F \tag{2.65}$$

In order to find equilibrium values of *X* and *n* depending on parameters α, β, σ and L_F we need to apply a certain restriction of the function *f(X)*. In order to ensure the existence and the uniqueness of the equilibrium, the *f(X)* should satisfy the following conditions: $f(0)>0$, $f(\infty)<\infty$, $f'(0)=\infty$, $f'(\infty)=0$, $f'''(X)<0$. Function $f(X)=e^{-1/X}$ satisfies all the required criteria and is used to provide a detailed numerical solution of the model.

Hence using $f(X)=e^{-1/X}$ and (2.61) and (2.65) we can get:

$$\frac{f(X)(\alpha+\delta)}{f'(X)(\sigma-1)} - (\delta+\alpha)X - L_F(1-z) = 0 \tag{2.66}$$

$$\frac{(\alpha+\delta)}{(\sigma-1)}X^2 - (\alpha+\delta)X - L_F(1-z) = 0 \tag{2.67}$$

$$X = \frac{(\alpha+\delta)+\sqrt{(\alpha+\delta)^2+\dfrac{4(\alpha+\delta)(1-z)L_F}{(\sigma-1)}}}{\dfrac{2(\alpha+\delta)}{(\sigma-1)}} \tag{2.68}$$

Now using (2.65), the model can be solved for unique value of *n* in steady-state equilibrium:

$$n = \frac{E(1-z)}{\sigma W\left[X\left(\delta+\alpha\right)+L_F(1-z)\right]} \tag{2.69}$$

2.12. Appendix. Profit Maximization: Open Economy

A firm chooses the time paths of L_Y and L_R to maximize over infinite horizon, with the discounted value of its profits given by:

$$\pi = PY - W(L_F + L_Y) + W^* L^*_R \tag{2.70}$$

Profit can be represented as:

$$\pi = \frac{E[(\sigma W)/(\sigma-1)e^{\beta S}]^{1-\sigma}}{\sigma}\left(E/\overline{P} + E^*(T^*-1)^{-\sigma}/\overline{P}^*\right) f(\xi^*)^{\sigma-1} - WL_F - W^* L^*_R \tag{2.71}$$

$$C = \frac{[(\sigma W)/(\sigma-1)e^{\beta S}]^{1-\sigma}}{\sigma}\left(E/\overline{P} + E^*(T^*-1)^{-\sigma}/\overline{P}^*\right) \tag{2.72}$$

$$\pi = Cf(\xi)^{\sigma-1} - WL_F - W^* L^*_R \tag{2.73}$$

Thus the firm entering at time zero will maximize

$$V = \int_0^\infty e^{-\rho t}\pi(t)dt \tag{2.74}$$

subject to the following constraint implied by (2.25) and (2.37):

$$\dot{\xi}^* = L^*_R(t)(1-z) - \frac{\alpha}{\varphi}\xi^* \tag{2.75}$$

$$H = Cf(\xi)^{\sigma-1} - WL_F - W^* L^*_R + \lambda((1-z)L^*_R - \frac{\alpha}{\varphi}\xi^*) \tag{2.76}$$

The first order conditions for a maximum are obtained imposing:

$$\frac{\partial H}{\partial X} = -\dot{\lambda} + \rho\lambda \tag{2.77}$$

$$\frac{\partial H}{\partial L_R} = 0 \tag{2.78}$$

$$\lim_{t\to\infty}\lambda(t)X(t) = 0 \tag{2.79}$$

Again, since $\nu(\cdot)=\pi(\cdot)$ and $g(\cdot)=\xi^*(\cdot)$ are both concave in X and L_R, then the necessary conditions are also sufficient [11].

Steady state solution

Use (2.28), (2.30), (2.77), (2.78) to find:

$$\frac{f'(x)}{f(x)}=\frac{nW^*((\alpha/\phi+\delta))\overline{P}^{\sigma-1}\sigma}{(\sigma-1)(1-z)\overline{E}} \tag{2.80}$$

where $\overline{E}=[E/\overline{P}+E^*(T^*-1)^{-\sigma}/\overline{P}^*]$

In the steady state, where $\xi^*(t)=\xi^*$ (constant), the profit of each firm equals the discounted value of its excludable knowledge:

$$\int_t^\infty e^{-\rho t}\pi(t)dt=\lambda(t)\xi^* \tag{2.81}$$

λ - shadow price of ξ^*

$$\dot{\xi}^* = L_R^*(t)(1-z)-\frac{\alpha}{\phi}\xi^* = 0$$

$$\frac{\dot{W}}{W}=\frac{\dot{E}}{E}=\rho-\delta$$

From (2.81):

$$\delta W^*\xi^* = Cf(\xi^*)^{\sigma-1}-W(\frac{\alpha/\phi\xi^*}{(1-z)}+L_F)$$

$$\frac{(\alpha/\varphi+\delta)}{(1-z)}\xi^* = \frac{E}{n\sigma W^*}-L_F \tag{2.82}$$

In order to find equilibrium values of $\gamma\xi^*$ (the share of excludable foreign knowledge purchased by a home country firm) and n depending on parameters α, β, σ W, W^* and L_F we need to apply certain restrictions of the function $f(\xi)$. In order to ensure the existence and the uniqueness of the equilibrium, the $f(\xi)$ should satisfy the following conditions: $f(0)>0$, $f(\infty)<\infty$, $f'(0)=\infty$, $f'(\infty)=0$, $f'''(\xi)<0$. Function

$f(\xi)=e^{-1/\xi}$ satisfies all the required criteria and is used to provide a detailed numerical solution of the model.

Hence using $f(\xi)=e^{-1/\xi}$ and (2.61) and (2.65) we can get:

$$\frac{\left(\frac{\alpha}{\phi}+\delta\right)W^{*}\bar{E}}{(1-z)(\sigma-1)}\xi^{2}-\frac{W^{*}\left(\frac{\alpha}{\phi}+1\right)}{(1-z)}\xi-WL_{F}=0 \tag{2.83}$$

Using (2.82), the model can be solved for unique values of ξ^{*} and n in steady-state equilibrium:

$$\xi^{*}=\frac{\left(W^{*}\left(\frac{\alpha}{\phi}+1\right)+\sqrt{\left(W^{*}\left(\frac{\alpha}{\phi}+1\right)\right)^{2}+\frac{4L_{F}WW^{*}\left(\frac{\alpha}{\phi}+\delta\right)}{(1-z)(\sigma-1)}}\right)*(\sigma-1)}{W^{*}\left(\frac{\alpha}{\phi}+\delta\right)\bar{E}} \tag{2.84}$$

$$n=\frac{\left(\frac{\alpha}{\phi}+\delta\right)W^{*}\sigma}{(1-z)(\sigma-1)\bar{E}\xi^{*}} \tag{2.85}$$

2.13. Appendix. Notation Guide

A	Technology
D(i)	Demand for variety *i* at the time *t*
E	Total expenditure on all varieties produced
$L_F(i)$	Fixed amount of labour needed for variety *i* production
$L_Y(i)$	Variable amount of labour needed for variety *i* production
$L_R(i)$	Amount of labour used in knowledge production
P(i)	Price of variety *i* at time *t*
S	Spillover stock of knowledge
V	Total discounted value of firm's profit
W(t)	Wage rate at time *t*
X(t)	Firm's excludable stock of knowledge at time *t*
Y(i)	Output of variety *i*
α	National knowledge spillover rate
α / ϕ	International knowledge spillover rate
δ	Discount rate
ρ	Rate of interest
σ	Elasticity of substitution between any pair of varieties
Z	Piracy rate
N	Number of firms in the industry
λ	Shadow price of the excludable stock of knowledge
ξ	Foreign firm's excludable stock of knowledge
φ	Share of the spillover stock of knowledge produced in the foreign country that becomes available to the firms in the home country
γ	Share of the excluded knowledge produced by a foreign country firm purchased by a home country firm.

Chapter 3. International Trade and Productivity: Firm-Level Evidence from Ukraine

3.1. Introduction

In the last quarter-century, there has been a considerable increase in the openness of the Ukrainian economy. The percentage of Ukrainian exporting firms has risen sharply after the collapse of the Soviet Union in 1991, and has been exhibiting strong positive dynamics since then. At the same time, the structure of Ukrainian exports has undergone through some significant changes. Raw materials and semi-processed products that constituted the largest part of the Ukrainian export during the 1990s have been partially replaced by the manufactured products of higher levels of processing.

In the current chapter, the research focus is on exploring export-productivity linkages at the level of individual firms on the basis of the database covering the main output sectors of the Ukrainian economy for the period 2000-2005. During the past decade, and increasing number of studies has emerged on the link between exporting activity and productivity at the micro-level. The literature has suggested a number of ways by which engaging into international trade could be beneficial to the growth of firms as well as aggregate productivity growth.

Two alternative hypotheses of the causal link between exporting activity and productivity performance have been widely discussed. The first is the self-selection hypothesis which is based on the commonly known fact that companies engaging in exporting have to overcome barriers to export and make some prior investments in order to compete effectively in overseas markets. The costs associated with exporting are known as sunk-costs, and these include the costs of marketing, distribution, establishing foreign networks and others. Hence, according to the self-selection hypothesis, only more productive firms are able to enter and successfully operate in foreign markets, while firms with lower productivity remain purely domestic. This hypothesis raises the question of whether there is a further learning effect from operating in international markets. It is logical that firms operating in the international markets have better access to the new knowledge and technical expertise through their international contacts, which should result in further advances in their productivity.

Several recent studies have addressed the importance of these two hypotheses in explaining productivity differences between exporting and non-exporting companies.

Bernard and Jensen (1999) addressed these two questions using micro-data for the US; Clerides, Lach and Tybout (1998) - for Columbia, Mexico and Morocco; Aw and Hwang (1995) - for Taiwan; Aw, Chung and Roberts (2000) - for Taiwan and Korea; Delgado, Farinas and Ruano (2002) - for Spanish firms; Baldwin and Gu (2003) - for Canada; and Harris and Li (2007) - for the UK. All authors found strong empirical evidence supporting the self-selection hypothesis. However, much less support has been found in favour of the learning-by-exporting hypothesis[13].

Thus in the scope of the current study I use firm-level data from Ukraine to assess the influence of exporting on productivity growth within firms across a set of manufacturing and service sectors. The main purpose of this chapter is to study differences in economic performance between exporters and non-exporters. First I estimate the unbalanced panel of Ukrainian firms for the years 2000-2005 to consider whether exporters are more productive prior to entry into overseas markets and/or whether there is also a post-entry learning-by-exporting effect. Furthermore, I study the differences in the effect of foreign market participation for 14 manufacturing and 5 service sectors separately.

The rest of the paper is organized as follows. Section 3.2 provides a review of the relevant literature. Section 3.3 contains a brief overview of the main trends in Ukrainian export dynamics. Section 3.4 provides the descriptive statistics of the data used in the analysis. Section 3.5 describes the methodology used for the estimation of the TFP and presents econometric estimates of the production function for the whole sample and for separate industries. Section 3.6 describes the methodology used to estimate the differences in the TFP of exporting and non-exporting firms, and presents the results of the estimation for the matched sample of firms for the whole sample and for separate industries (for the list of industries refer to Appendix 3.8). Section 3.7 provides the conclusion.

[13] Please refer to Greenaway and Kneller (2005) for the summary of the evidence.

3.2. Literature Review: Export and Productivity Links

In recent years, the topic of the impact of international trade on a firm's productivity and performance has become increasingly popular, leading to a growing body of literature. Emerging interest in the firm-level evidence can be partially explained by the availability of high quality micro-level data, and partially by the development of new approaches in theoretical modelling and new econometric techniques, which allowed exploring particularly large and tangled datasets.

As a result of the availability of more developed econometric methodologies, recent empirical research on the exporting-productivity links proves the existence of the positive relation between productivity and exporting. However, the direction of this relation still remains unclear: whether causality runs from productivity to exporting, vice versa, or in both directions. Most of the authors examined these issues by testing two alternative hypotheses.

The first one is a *self-selection* hypothesis which presumes that, on average, firms entering export markets have higher productivity prior to entry as compared to firms that remain purely domestic. This hypothesis is supported by the substantial factual evidence of differences in characteristics between exporting and non-exporting firms. Stylized facts from a number of countries suggest that, on average, exporting firms are more productive and more capital intensive; they pay higher wages and have larger scale of operation. The reasons of a relatively better performance in the case of export-oriented firms are easy to derive. First of all, entrance to and successful operation on the export market depends upon the ability of the firm to face and successfully overcome significant competition from the side of foreign rivals. Another reason of a better exporter's performance is the existence of sunk entry costs, which means that potential exporters have to be more productive than their domestic rivals to afford the fixed costs of entering a foreign market.

An alternative, but not excluding, is a *learning-by-exporting* hypothesis, which means that those firms which manage to enter the export market benefit from further increase in their productivity growth even after the entry took place. The reasons for this include access to the new, better technologies, product designs, technical expertise, and better managerial practices, which contribute to the overall improvement of the manufacturing process. Moreover, higher intensity of the foreign market competition also contributes to productivity boost of the new exporters. However, this proposition has not been as widely confirmed by the results of empirical as well as the theoretical studies.

The theoretical models developed by Melitz (2003) and Bernard *et al.* (2003) provide theoretical proof that firms have to be more productive to overcome sunk costs and enter global markets.

Melitz (2003) developed a dynamic industry model with heterogeneous firms to analyze intra-industry effects from international trade. The author incorporated firm heterogeneity into Krugman's model of trade under monopolistic competition and increasing returns. The model developed in the paper relies on the work of Hopenhayn (1992a, 1992b) to explain the endogenous selection of heterogeneous firms in the industry. Hopenhayn uses profit maximising decisions of identical firms that are not aware of their current and future productivity to construct the equilibrium distribution of their productivity. Melitz adapted Hopenhayn's model to a monopolistically competitive industry in a general equilibrium setting (Hopenhayn considered the case of perfect competition). The main contribution of the Melitz paper is that it provides a general equilibrium model with heterogeneous firms, yet it remains easily tractable. In order to achieve this, the author integrated firm heterogeneity in such a way that for the aggregate outcome the relevance of the distribution of firm's productivity is summarized by an average firm productivity level. After the average productivity level is determined, the aggregate outcomes of the model become identical to those of the model with identical firms all sharing the same productivity level. The analysis was based on the Dixit and Sitglitz (1977) model of monopolistic competition, and focused on the long-term effects of trade on the behaviour and performance of firms that differ in productivity levels. The paper also endogenises the number of product varieties in the model, and lets it vary with the country's openness to trade, measured by the number of exporting firms. One of the important innovations of the Melitz (2003) paper was the introduction of the dynamic forward-looking entry decision of firms facing the sunk costs of entering foreign market. The main finding of the paper stated that only more productive firms will enter export markets, while less-productive will remain purely domestic and the least productive will be forced to exit. The analysis also shows that a further increase in the industry's exposure to trade will lead to additional inter-firm reallocations towards more productive firms, which in its turn will increase aggregate industry productivity growth and lead to welfare gains.

Bernard, Eaton, Jenson and Kortum (2003) adapted the Ricardian trade model to firm specific comparative advantage, also introducing firm heterogeneity. However, in this paper, firms competed to produce the same product variety and the competition included foreign as well as domestic firms. To account for the heterogeneity of firms, the authors introduced the Ricardian differences in technological efficiency across firms and countries. In order to explain the coexistence of domestic and export-oriented firms within the same industry, the costs of exporting were introduced in terms of a standard 'iceberg' assumption, which means that exporting costs to a given destination are proportional to production costs. Furthermore, in order to allow for the technological differences to be fully reflected in output and prices, the authors introduced imperfect competition with variable mark-ups; thus the authors introduced Bertrand competition into the Ricardian frameworks with a given set of goods. Thus the paper operated on the assumption that the total number of product varieties consumed and produced in the world is fixed and based on a specific parameterization of the distribution of the productivity levels. The authors further calibrated their model to fit a combination of micro and macro US data, and obtained comparative static results by simulating the model.

A simple model by Lopez (2004) shows that one of the possible explanations of the self-selection pattern is that a company consciously attempts to increase its productivity via investment in R&D activities and new technologies, with the explicit purpose of becoming an exporter. The explanation/motivation for such models comes from the fact that goods made for export in developing countries are usually of better quality than the analogous goods produced for the local market (e.g. Keesing, 1983; Keesing and Lall, 1992). Hence, to become an exporter, the company, attracted by the prospects of higher returns in the international market, has to improve the quality of its products by introducing new technologies. The adoption of the new technology in its turn requires the firm to become more productive and increase its absorptive capacity in order to be able to absorb the technology and internalize the new knowledge. A similar idea was also developed in a paper by Hallward-Driemeier, Iarossi and Sokoloff (2002); however they did not limit the discussion to more productive firms, but instead tried to show that firms target export markets from the initial date of operation, and design their investment decisions and technology activities in a way that will allow them to increase their productivity. This is also supported by a large amount of anecdotal evidence and several case studies. Surely there are many other factors that influence a firm's productivity (i.e. the quality of the personnel, managerial practices, and other external factors). However, the benefits of exporting might still play an important part in the increase of the productivity of the firms in developing countries.

Another important contribution was made by Nocke and Yeaple (2008) who introduced a model where firms invest in two technologies characterised by different unit production costs. They further showed that a reduction in trade costs stimulates firms to switch from high-cost to low-cost technology which in turn leads to an increase in productivity.

Also, recent empirical research on the basis of firm-level data provides strong empirical evidence in favour of the self-selection hypothesis, confirming the existence of significant productivity differences between exporting and non-exporting establishments. Several empirical studies, such as those of Bernard and Jensen (1999), Girma *et al.* (2004), Baldwin and Gu (2004), Greenaway and Kneller (2005), Aw, Chang and Roberts (2000), and Clerides, Lack and Tybout (1998) have addressed the issue of self-selection.

Two recent papers by Wagner (2005) and Greenaway and Kneller (2005) provide a review of the majority of the empirical literature on self-selection. Numerous papers find empirical support for the hypothesis in different countries; for example, Aw and Hwang (1995) developed an empirical model to study the impact of resource-level differences and productivity differences on the output levels of exporting and non-exporting firms of the Taiwanese electronic industry. The results of the model show that the bulk of the output differences between exporters and non-exporters can be explained by the larger size of exporting firms. However, the authors also found significant differences in productivity levels between exporters and non-exporters.

A study by Bernard and Wagner (1997) examined the differences in characteristics and performance between exporters and non-exporters in German manufacturing. Their findings show that exporting firms have decidedly better performance attributes when compared with non-exporters, even within the same industry. Moreover, while the wage differences are quite modest, productivity of exporters is much higher. However, explanations of these findings show that the causality runs from performance to exporting, because several years before entering overseas markets exporters already possessed the majority of superior characteristics, i.e. they are larger, more productive and pay higher wages. In the years prior to entering export markets, these future exporters showed faster levels of growth in employment, shipments and productivity.

Clerides, Lach and Tybout (1998) also analyzed the causal links between exporting and productivity, using firm-level panel data from Morocco, Mexico and Colombia. They studied the shift in the firms' stochastic cost processes after breaking into foreign markets. They found that relatively efficient firms become exporters. However, previous export market participation does not decrease unit costs of exporting firms. Hence the efficiency gap between exporters and non-exporters is the result of the more efficient firms self-selecting into the export markets, and not the result of learning-by-exporting. The authors also found that exporters reduce the sunk costs of entering foreign markets for domestic firms. However, such a decline in sunk costs does not make domestic produces more efficient.

Bernard and Jensen (1999) used the US panel data to address the issue of export benefits to individual exporters and a contribution of exporting activity towards economic growth as a whole. The results of the analysis do indicate that better performing firms become exporters in the first place; however, the benefits of exporting are much harder to locate. The main benefit of exporters is increased probability of survival. However, the paper concludes that current exporting status is a poor prediction of future performance, especially over medium- and long-term horizons: only employment growth is significantly higher for today's exporters over the long term, while shipment volumes, productivity and wages show much slower growth dynamics.

Among the studies addressing the linkages between exporting and productivity in developing countries, that of Kraay (1999) shows significant positive productivity gains from exporting for a panel of 2105 Chinese industrial enterprises between 1988 and 1992. Controlling for past performance and unobserved firm characteristics, he found that an exporting activity record leads to significant improvements in enterprise performance. Moreover, he found that these learning effects are most pronounced among established exporters, while for new entrants to export markets, learning effects are insignificant and occasionally negative.

Also, Alvarez (2001), in his work on the Chilean manufacturing industry, studied the impact of the outward orientation variables on technological innovation as being one of the most important sources of productivity growth. Using firm-level data, he identified three main channels of new technology absorption: exports, direct foreign investment and purchases of technical licences. The results of the study suggest that export is the most effective in increasing technological innovation, while FDI and technical licence purchases improve only a limited number of technological indicators.

Castellani (2002) used the data on Italian manufacturing firms in order to estimate the impact of export behaviour on productivity growth rate. He found that, when export behaviour is expressed in terms of export intensity, it has a positive and significant effect on TFP growth. However, if it’s measured as a dummy reflecting a firm's participation in the export market, its impact on TFP growth becomes insignificant. In other words, empirical findings suggest that export market participation does not lead to learning *per se*. Benefits from internationalization only arise after an exporter has achieved a high degree of involvement in international activities and accumulated enough specific knowledge and practices.

Delgado, Farinas and Ruano (2002) measured TFP difference between exporting and non-exporting firms in Spanish manufacturing. The authors documented these productivity differences on the basis of a panel sample of Spanish manufacturing firms over the period 1991–1996. Furthermore, the paper compared the cumulative distribution functions of TFP for different groups of firms: exporters, non-exporters, entering exporters and exiting exporters. These distributions were ranked using the concept of stochastic dominance, and their differences were formally tested using the Kolmogorov–Smirnov one- and two-sided tests. Third, the paper attempted to sort out self-selection versus learning-by-exporting propositions for the higher productivity of exporting firms. For this purpose the authors compared productivity levels and growth for groups of exporting and non-exporting firms. The findings confirm higher levels of productivity for exporters, with the results driven by the self-selection of more productive firms into the export market. Learning-by-exporting evidence, on the other hand, is rather weak, and limited to younger exporters. These results are very much in line with those of Clerides, Lach and Tybout (1998) and Bernard and Jensen (1999).

Although the methodology used differs throughout their research, all three studies mentioned above reached a similar conclusion: self-selection rather than learning-by-exporting is the factor that leads to higher productivity of exporting firms with respect to non-exporting firms.

Another study, that of Farinas and Martin-Marcos (2003), measured economic performance differences between exporters and non-exporters on the basis of an unbalanced panel of Spanish manufacturing firms over the period 1990-1999. The authors studied differences in several performance measures, such as labour productivity, investment, wages, the composition of labour force, R&D activities, etc. Furthermore, the paper studied ex-ante differences in performance between exporting and non-exporting firms and ex-post differences in their evolution. The paper also measured the differences in total factor productivity between exporters and non-exporters by estimating production function. The authors applied estimators developed by Arellano and Bond (1998), Arellano and Bover (1995) and Blundell and Bond (1998). The paper provides support in favour of both self-selection and learning-by-exporting hypotheses.

However, some studies still find that there is little difference in productivity between exporters and non-exporters. This conclusion appears mostly in the papers that study micro-level data from the advanced, developed countries with stable, non-increasing, export shares.

One of the examples is the study by Bleaney and Wakelin (2002), in which they found that non-innovating firms are more likely to export having lower unit labour costs, while innovating firms have a higher probability of exporting when they have accumulated a higher number of innovations. Thus the probability that a firm is an exporter is higher if the firm operates in a sector with high R&D. For non-innovating firms, the probability of becoming an exporter is higher if the firm operates in a sector with low capital intensity.

Also, Greenaway *et al.* (2005) found little difference in the efficiency between exporters and non-exporters for Swedish manufacturers that have a relatively high average level of international exposure. Damijan *et al.* (2005) found that, in Slovenia, higher productivity levels affect the probability of exporting only when the exporting firm is oriented to markets in advanced countries, and, in case the export is aimed at other developing nations, productivity differences have no significant impact on the probability of exporting.

One of the recent papers by Harris and Li (2007) also explored the presence of both self-selection and learning-by-exporting effects using a weighted FAME database to obtain a representative sample of the population of the UK manufacturing and service firms. The results for the 16 UK industries confirm that overall, in the year prior to entering the international markets, future exporters usually possess a number of superior characteristics compared with non-exporters: they are older, have higher labour productivity and higher intangible assets. Furthermore, the authors estimate learning-by-exporting effect by implementing instrumental variables, control function and matching approaches to address the problems of endogeneity and sample-selection. The results of the estimation for the 16 industries confirm the presence of a significant productivity gains from exporting. However, the results for separate industries vary substantially, with post-entry/exit productivity gains/losses being present in some industries but not in others. The authors suggest that the ability to internalise benefits from exporting depends to a high extent on the "firm specific assets (i. e. absorptive capacity) and knowledge accumulation" [12].

Yet much controversy remains with respect to the empirical linkages between exporting and productivity growth, and no universal conclusion has been reached so far as to whether the learning-by-exporting hypothesis holds. A number of empirical studies failed to find any significant impact of exporting on productivity levels in the post-entry period, with the majority of findings being that firms on average have significantly higher growth levels in terms of employment and wages after entering export markets (Bernard and Jensen 1999, 2004c; Bernard and Wagner, 1997).

However, with the development of new econometric techniques some positive effects on learning-by-exporting have been identified, especially in the cases of developing countries (Castellani, 2002; Hallward-Driemier *et al.,* 2002; Blalock and Gertler, 2004; Fernandes and Isgut, 2005; Yasar and Rejesus, 2005).

Also several studies found evidence in favour of both self-selection and learning-by-exporting effects (Baldwin and Gu, 2003; Girma *et al.,* 2004; Greaway and Yu, 2004).

There are several reasons for such a wide range of empirical results stemming from the empirical studies discussed above. First of all, depending on the country of interest, the analysis implemented using similar set of techniques may lead to completely different results. For example, Baldwin and Gu (2004) found significant learning effect in Canadian plants, while Bernard and Jensen (2004c), in their study of US manufacturing firms, found no evidence of productivity gains associated with exporting. The nature of such results can be explained by the difference in sizes of the Canadian and US economies as well as by the intensity of domestic competition and varying levels of R&D investment. As a result, increase in export exposure provides Canadian plants with an access to the leading international technologies and to larger markets characterised by the more intense competition, which transforms into productivity growth acceleration. At the same time, US manufacturing firms can acquire relatively little gain from international market exposure, due to the relatively large size of the domestic market and superiority of domestic technologies over their international counterparts. Also, the amount of productivity gains coming from exporting depends to a high extent on the characteristics of specific export markets. Blalock and Gertler (2004) and Damijan *et al.* (2004) argue that significant productivity gains arise only when exporting is targeted at the advanced export markets of industrialized countries, while exporting to the markets of similar levels of economic development leads to small or in some cases insignificant productivity gains. This conclusion is supported by the results of the majority of empirical studies that find evidence in favour of the learning-by-exporting hypothesis based on the data from developing countries, i.e. countries with increasing export shares, changes in the export structure, and low technological frontiers; much less support has been found in the case of developed countries characterized by stable export shares and considerable technological advances. It should also be emphasized that numerous methodological issues arise when testing the effect of exporting on productivity. One of the most common problems is the sample-selection bias. The nature of the bias suggests that exporting firms might possess some unobservable characteristics that make them more productive than their domestic counterparts, thus allowing them to overcome sunk cost and enter the export markets. Thus estimating the learning-by-exporting effect using conventional econometric routines would lead to biased and spurious results[14].

[14] Please refer to Section 3.4 for a detailed analysis of methodological issues.

3.3. Overview of Ukrainian Export Dynamics

Ukraine has a well-developed industrial base inherited from the USSR. It has rich farmlands and quite a lot of mineral resources which are used for exports as well as for domestic consumption. Although the Ukrainian export structure has undergone significant changes over the past decade, the main part of it still consists of fabricated ferrous and nonferrous metals, chemicals, machinery, fuel and petroleum products, transport equipment and food products. In 2008, the country's gross domestic product had an estimate of 950 billion UAH (which equals to £85.45 billion)[15], of which some £40 billion (that is 47%) came from exports.

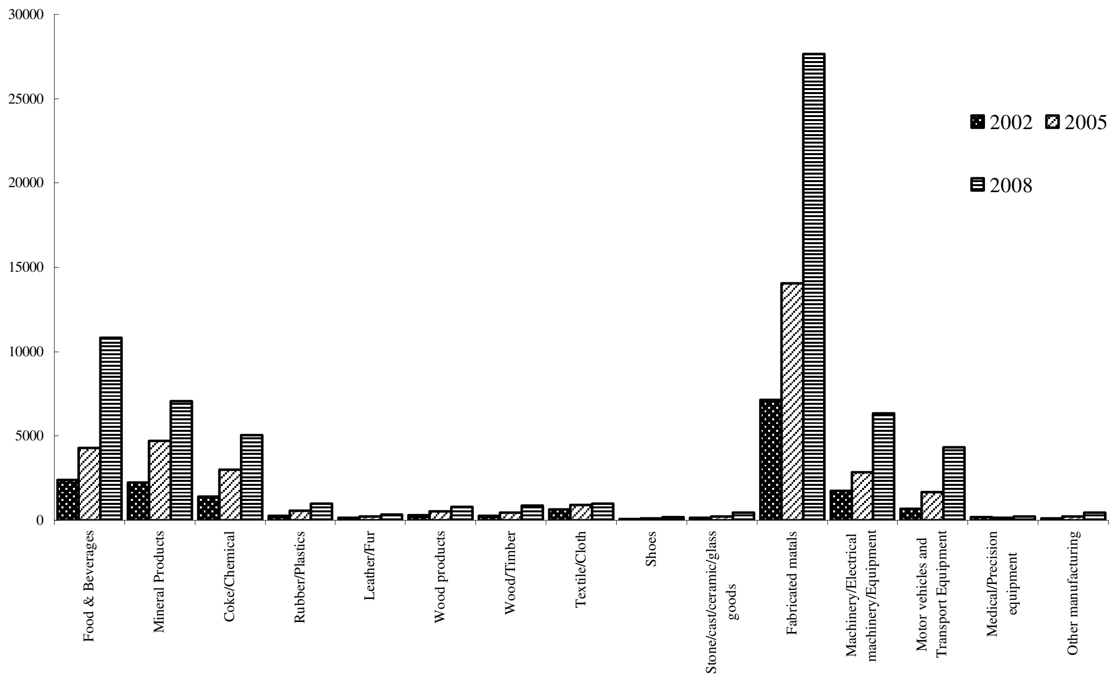
The geographical structure of Ukrainian exports (Figure 3.1) shows the dominance of exports to the CIS countries, with the main trading partners being Russia, Kazakhstan and Belarus. However, export share to the EU countries has been exhibiting strong positive dynamics. The main export partners among the EU countries are Germany, Spain, Italy, Poland, Latvia, Lithuania and the Czech Republic. A significant amount of export also goes to the USA and China.

Ukraine has seen much financial gain from exports. The country has immense agricultural and industrial resources; and despite suffering almost a decade of economic decline during the 1990s, it has emerged as a country of high economic importance. Since the turn of the century, the country's economic growth averaged 7.4% a year, but this dropped to about 2.1% in 2008.

During the last eight years, Ukraine has been increasing the amount of international trade generating more trading partners worldwide (Figure 3.2). The dynamics of the Ukrainian geographical export structure through 2002-2008 clearly shows an increase in the amount of international trade with EU countries, as well as Asia and the USA. The product structure of Ukrainian exports also reflects positive dynamics with a significant increase in the level of exports of such manufacturing sectors as food and beverages, coke, chemical and nuclear products, fabricated metals, machinery, electrical machinery and equipment, motor vehicles and transport equipment. This tendency means that the Ukrainian exports structure, which has consisted mostly of raw materials exports, has been gradually changing with more and more manufacturing products being sold overseas.

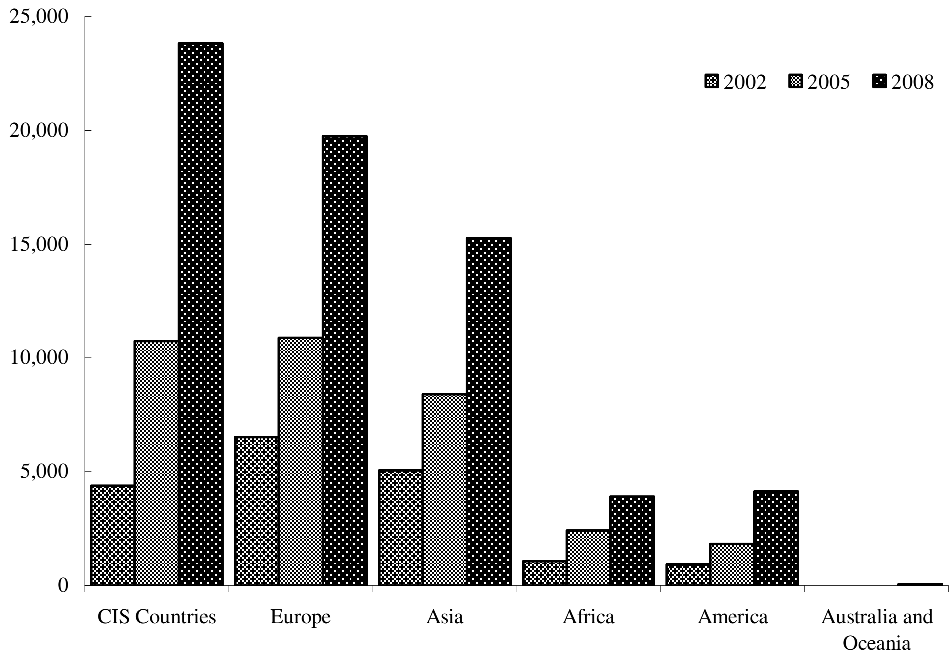
[15] Data source: Ukrainian State Statistic Committee and National Bank of Ukraine.

Figure 3.1. Ukrainian exports structure, selected industries, 2002-2005-2008



Note: Data have been taken from the Ukrainian State Statistic Committee website; million USD

Figure 3.2. Ukrainian geographical exports structure, 2002-2005-2008



Note: Data have been taken from the Ukrainian State Statistic Committee website; million USD

3.4. Data and Descriptive Statistics

This section describes the sources and construction of the database in use, and provides basic descriptive statistics of the sample characteristics.

The dataset is constructed on the basis of the database which groups annual accounts data on the population of firms operating in Ukraine. All firms are uniquely defined by their VAT (OKPO) number and divided into sectors according to the Ukrainian Office of National Statistics (Derjkomstat) nomenclature, which is comparable to the NACE[16] classification commonly used for European Statistics. Furthermore, the sectors are grouped so that they correspond to the NACE classification.

The data contain basic information on firm-specific characteristics, such as employment, output, sales, overseas sales, assets, 2-digit industry code, different types of intermediate expenditures (including R&D and innovation expenditure) and investment. The age of the firm is calculated by adding the number of times (years) the firm enters the dataset. The data have been compiled from the National Institute of Statistics, checked and cleaned for consistency.

The final dataset used for statistical analysis comprises an unbalanced panel with 337,057 firms and 1,077,292 observations covering the period 2000-2005, with information showing entry and exit from export markets.

The set contains information on firms in 22 industries based on the 2-digit NACE industry code. Appendix 3.8 contains summary statistics on the number and the percent of exporting firms by industry. The average annual number of firms in the sample is 179, 432, while the average annual percent of exporting firms in the sample is 5.6% (Table 3.1).

Table 3.1. Number of firms, share of exporter (%) by year, 2000-2005

Year	2000	2002	2003	2005	Average
Number of firms	138,171	186,578	191,760	184,829	179,432
Number of exporters	8,694	10,307	10,848	8,005	9,909
Share of exporters, %	6.3%	5.5%	5.7%	4.3%	5.6%

Note: Database used in the analysis

[16] The NACE Revue 1 classification can be downloaded from the Eurostat Ramon server: http://ec.europa.euostat/ramon/nomenclatures/

Table 3.2 contains summary statistics for the basic variables - output, capital, employment and material costs - for selected years. The statistics reflect declining average employment size, increasing output and material expenditure. The capital, on the other hand, shows a mild negative trend.

Table 3.2. Means (standard deviation) of production function variables (2000, 2003, 2005)

	2000	2003	2005
Output (Value added)	1692.248	2061.05	5303.714
	(43923.67)	(51019.31)	(124614.1)
Employment	54.51899	37.77886	24.62973
	(762.04)	(646.03)	(429.79)
Materials	3648.21	6348.605	5974.771
	(49598.52)	(79180.38)	(107172.1)
Capital	3097.747	2467.321	1858.925
	(60613.25)	(53056.17)	(33621.67)

Note: Capital, materials and output are expressed in constant 2000 prices, thousands of UAH.

The sample statistics might cause a concern that large firms might be over-represented in the sample (as in case of the Annual Respondents Database (ARD) in the UK). However, according to the Enterprise Survey data collected by the World Bank Group[17] Ukrainian firms are among the largest in the Eastern European and Central Asian (ECA) region in terms of permanent and temporary workforce. In particular, the survey reports that Ukrainian firms have the sixth largest permanent workforce in the ECA region. The average firm in Ukraine employs 56.8 permanent workers, while average ECA firm employs only 44.0 workers, and an average EU-10 firm – only 37.3 workers. Moreover, firms in manufacturing are more than twice as large as those in retail and other services. And exporters are at least double the size of non-exporters.

However, in case the sample dataset is skewed towards large establishments one can generalise the results by using the information on the population of individual firms (in case such information is available) in order to weight the financial data and get population estimates. For example, as discussed in Harris (2005), the ARD data contains information on the UK manufacturing establishments (addressed as reporting

[17] http://www.enterprisesurveys.org/; The survey was conducted between June and August 2008 and included 851 firms.

units), which sometimes can consist of several individual firms. When conducting analysis based on such data it is important to bear in mind that reporting units in this case are not economic, but accounting units. Thus, they can undergo through significant restructuring overtime due to purchase/selling of separate production units; openings/closures of production units; or due to changes in the way they report their accounting information to the Office of National Statistics (ONS). Such changes in the reporting units' structure imply that the units are not 'stable' over time, which breaks down the requirement for the analysis of firms' openings and closures, or for the use of perpetual inventory approach when measuring capital stock. Fortunately, the ARD data is constructed in such a way that reporting units' information can be broken down to the individual firms' level (using individual employment shares and the unique reference numbers given to each production unit). However, this exercise in itself might cause a number of problems. For example, when deriving firm-level data from the reporting units' data based on employment shares, one has to assume a constant investment-labour ratio (or labour productivity) for all the production units included in the reporting units'. Moreover, the use of the firm-level data (derived in a way described earlier) for the econometric analysis might result in lower standard errors, as figures derived out of the establishment level data would likely to have lower variance than in case if the data was available for each individual firm. Overall, as noted by Harris (2005), it is hard to measure the bias that arises if firm-level data is obtained from the reporting unit level data. Moreover, it is hard to conclude whether this technique would introduce any bias into further econometric analysis implemented on the basis of such dataset.

In the framework of the current study, the dataset doesn't have enough information that would allow us to reconstruct the data on each individual firm and to calculate sample 'weights'. Thus, we proceed further using the data at hand.

Next, I calculate the annual percentage of the exporting firms in each industry to identify most/least export intensive industries (Table 3.3).

This simple analysis reveals persisting prevalence of raw materials and semi-processed goods in the Ukrainian export structure. Most export-oriented industries are agriculture/forestry/fishing, mining/quarrying, coke/nuclear/chemical, wood/wooden products and transport equipment; the share of exporting firms in these industries exceeds 15%.

Table 3.3. Export-intensive industries

NACE code	Industry	All firms	Exporters	Exporters %	% of Total	% of Sales exported
(A/B)	Agriculture/Forestry/Fishing	1,804	343	19.0%	0.5%	9.02%
(CA)	Mining/quarrying of energy producing materials	607	74	12.2%	0.2%	13.04%
(CB)	Mining/quarrying, except of energy producing materials	796	148	18.6%	0.2%	10.21%
(DA)	Food/Beverages/Tobacco	12,725	977	7.7%	3.8%	5.53%
(DB/DC)	Textile/Clothing/Leather/Fur	6,129	608	9.9%	1.8%	20.75%
(DD)	Wood/Wooden products (+36)	5,383	854	15.9%	1.6%	9.11%
(DF/DG)	Coke/Nuclear/Chemical	2467	424	17.2%	0.7%	7.86%
(DH)	Rubber/Plastic	2,412	275	11.4%	0.7%	5.11%
(DI)	Non-metallic minerals	4,326	365	8.4%	1.3%	15.4%
(DJ)	Basic/Fabricated Metals	5,120	630	12.3%	1.5%	9.44%
(DK)	Mashinery and equipment	7,545	913	12.1%	2.2%	8.15%
(DL)	Electrical and optical equipment	6,794	598	8.8%	2.0%	7.77%
(DM)	Transport equipment	1,583	250	15.8%	0.5%	7.78%
(DN)	Manufacturing n.e.c.	4,520	380	8.4%	1.3%	8.22%
(G pt1)	Wholesale	12,613	404	3.2%	3.7%	12.37%
(G pt2)	Retail trade	121,431	8473	7.0%	36.0%	5.63%
(G pt3)	Repair of motor vehicles	35,413	228	0.6%	10.5%	3.31%
(I)	Transport/Transport Sevices/Post	17,170	328	1.9%	5.1%	1.15%
(K)	Real estate/renting/business activities	54,567	583	1.1%	16.2%	2.62%
	Totals	**337,057**	**17,151**	**5.1%**	**100%**	**%**

Source: Own calculations

For further analysis, I used firms of the 14 manufacturing industries[18]; I also included transport/transport services/post (I), real estate/renting/business (K), wholesale/retail trade/repair of motor vehicles (G) sectors owing to the high percent of exporting firms.

[18] For the complete list of industries, refer to Appendix 3.8.

The producer price indices used to deflate firm-level sales as well as material inputs and investment are available from the Ukraine State Statistic Committee[19] website.

Next I followed the exercise used by Girma *et al.* (2005), Wagner (2006) and Harris and Li (2007), and tested the rank ordering of the total factor productivity (TFP) distribution of exporting versus non-exporting firms[20]. Using two-sided Kolmogorov-Smirnov statistics, I tested whether the productivity distribution of one sub-group of firms (exporters) lies to the right of another sub-group of firms. The null hypothesis states that the distributions of both subgroups are the same. However, rejection of the null hypothesis confirms the first-order stochastic dominance of the second group.

Table 3.4 shows that, in most of the industries examined, TFP distribution of exporting firms lies significantly to the right of that of non-exporters. Nevertheless, in some industries (agriculture/forestry/fishing; coke/nuclear/chemical; non-metallic minerals; machinery and equipment; and transport equipment), it is also possible to reject the null hypothesis that distribution of exporters lies significantly to the right of that of their non-exporting rivals. This result is a consequence of the crossover of the distributions of exporting versus non-exporting firms. In particular, in these industries, exporters dominate non-exporters for a major part of the distribution of TFP values, but at some levels non-exporters dominate exporters, which results in the distributions' cross-over[21]. However, this phenomenon is observed for the industries that specialize mainly in the exports of resources and products of low levels of processing. We can speculate that the trade advantage for the firms in these industries depends on access to natural resources, but not on the TFP *per se*.

[19] Ukrainian State Statistic Committee website: http://www.ukrstat.gov.ua/
[20] The analysis is based on the TFP estimated in section 3.5.
[21] Please refer to Appendix 3.16 for the examples of the diagrams showing the cross-over of the TFP distributions between exporting and non-exporting firms.

Table 3.4. Two-sample Kolmogorov-Smirnov tests on the distribution of TFP by various subgroups and industries, Ukraine, 2000-2005

NACE code	Industry	All exporters	All non-exporters
(A/B)	Agriculture/forestry/fishing	-0.275***	0.101***
(CA)	Mining/quarrying of energy producing materials	-0.003	0.279***
(CB)	Mining/quarrying, except of energy producing materials	-0.002	0.388***
(DA)	Food/beverages/tobacco	-0.003	0.085***
(DB/DC)	Textile/clothing/leather/fur	-0.005	0.086***
(DD)	Wood/wood products (+36)	-0.018	0.126***
(DE)	Paper/printing/publishing	-0.012	0.234***
(DF/DG)	Coke/nuclear/chemical	-0.091***	0.101***
(DH)	Rubber/plastic	-0.025	0.117***
(DI)	Non-metallic minerals	-0.068***	0.091***
(DJ)	Basic/fabricated metals	-0.009	0.181***
(DK)	Machinery and equipment	-0.053***	0.057***
(DL)	Electrical and optical equipment	-0.032	0.126***
(DM)	Transport equipment	-0.101 ***	0.024***
(DN)	Manufacturing n.e.c.	-0.006	0.428***
(E)	Electricity, gas and water supply	-0.000	0.620***
(G pt1)	Wholesale	-0.001	0.266***
(G pt2)	Retail trade	-0.004	0.208***
(G pt3)	Repair of motor vehicles	-0.023	0.103***
(H)	Hotels/restaurants	-0.003	0.319***
(K)	Real estate/renting/business activities	-0.001	0.248***
(L)	Public administration and defence	-0.212	0.516***
(O)	Community/social/personal service activities	-0.002	0.535***
(I)	Transport/transport services/post	-0.001	0.374***

Note: ***- significant at 1% level; **- significant at 5% level; *- significant at 10% level

3.5. Total Factor Productivity Estimation

This section will review some common issues emerging when estimating TFP, provide a short description of the available TFP estimation techniques, and conclude with an estimation of the TFP productivity of the dataset used in the analysis using several estimation methods.

Usually the studies on productivity on the firm level assume the production function (measured as deflated sales, gross output or value added) to be a function of inputs and productivity of the firm.

The standard approach to measure TFP implies estimating production function using equation (3.1) to obtain the elasticities of output with respect to inputs.

$$y_{it} = \alpha_0 + \alpha_E e_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha_T t + u_{it} \tag{3.1}$$

In equation (3.1) *y, e, m* and *k* stand for the logarithms of output, employment, intermediate inputs and capital stock in firm *i* at time *t*. Furthermore, α_0 is a mean efficiency level across firms and over time and u_{it} is a time- and producer-specific deviation from the mean value (Van Beveren, 2010). Following the standard approach the TFP is calculated in two steps. The first step estimates elasticities of output with respect to inputs ($\alpha_e, \alpha_m, \alpha_k$). And the second step obtains TFP as sum of the residual from the equation (3.1) and the time trend *t*:

$$\ln \hat{TFP}_{it} = \hat{\alpha}_t t + \hat{u}_{it} = y_{it} - \hat{\alpha}_e e_{it} - \hat{\alpha}_m m_{it} - \hat{\alpha}_k k_{it} \tag{3.2}$$

However, u_{it} can further be decomposed into two components; and one of them is observable (or at least predictable) for the firm. Thus, equation (3.1) transforms into:

$$y_{it} = \alpha_0 + \alpha_E e_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \alpha_T t + \omega_{it} + \varepsilon_{it} \tag{3.3}$$

Where $\alpha_0 + \omega_{it} = w_{it}$ stands for the firm-level unobserved productivity, which is not observable to the researcher, but observable for the firm. And ε_{it} is an i.i.d. error component. Intuitively w_{it} might be associated with such variables as managerial ability of the firm, break in production process due to equipment failures; expected defect rates in manufactured goods or expected amount of rainfall; while ε_{it} represents unexpected deviation from the expected levels of all the factors mentioned earlier.

Then we can measure TFP as a sum of the residual obtained from equation (3.1) and the time trend representing technological progress.

$$\ln T\dot{F}P_{it} = \hat{\alpha}_T + \hat{\alpha}_\omega \dot{\omega}_{it} \equiv \dot{y}_{it} - \hat{\alpha}_e \dot{e}_{it} - \hat{\alpha}_e \dot{m}_{it} - \hat{\alpha}_e \dot{k}_{it} \qquad (3.4)$$

3.5.1. Methodological issues of TFP estimation

According to the standard two-stage approach TFP is obtained using equations (3.1) – (3.2) as a combination of residual and time trend ($\hat{\alpha}_t t + \hat{u}_{it}$). In the second stage of the analysis estimated TFP measures are usually regressed against a range of TFP determinants, such as export status, age, intangible assets and others. However, since those variables were omitted from equations (3.1) – (3.2) and consequently assumed to be random, they automatically became a part of an error term (u_{it}), used to obtain the estimates of the TFP. Thus, when we use measures of TFP obtained through the two-stage approach to model TFP determinants, we are likely to get inefficient and biased estimates of the second-stage model parameters (Newey and McFadden, 1999; Wang and Schmidt, 2002). Such results appear due to several reasons. First, as discussed in Harris (2005), two-stage approach does not take into account any cross-equation restrictions. Furthermore, endogeneity of the TFP in equation (3.1) results in the correlation between error terms of the first and second stages of the analysis. Finally, due to the fact that some non-random determinants of output were not included in equations (3.1) – (3.2) the estimates of output elasticities (α_i) will be biased due to the omitted variable problem, which will lead to incorrect estimates for the TFP at the first stage. As discussed in Harris (2005), the bias can be disregarded only in case when the two sets of determinants (the ones that determine output and the ones that determine productivity) have zero correlation. However, since both sets of factors are firm-specific, the correlation between them is likely to be high. Moreover, as discussed in Wang and Schmidt (2002) there will also be a downward bias in all estimates obtained from the second-stage regressions.[22].

As a result of this discussion it would be beneficial to include all the potential output and TFP determinants in the equation (3.1) even when using two-stage approach. In this way the significance of all output determinants could be tested directly addressing the problem of inefficiency and omitted variable bias. As a result, we should also expect improvement in the estimates in the second stage of the analysis.

[22] Please refer to Wang and Schmidt (2002) for detailed explanation.

Overall, when TFP is estimated with the help of traditional OLS technique, such methodological issues as indogeneity of input choices; selection bias and omitted input/output price bias arise, leading to biased TFP estimates [23]. In what follows we will discuss these issues in somewhat more details.

3.5.1.1 Endogeneity of input choices

The use of the standard OLS procedure to estimate firm-level TFP would give us biased estimates of the inputs' coefficients. Indeed, in order to obtain unbiased estimates of the TFP, the production function coefficients should be exogenous. However, as noted by Marschak and Andrews (1944) and later discussed in Del Gatto (2010) and Van Beveren (2010) production inputs are not independently chosen, but determined by the specific firm characteristics, including its efficiency. The main reason for the '*endogeneity of inputs' or simultaneity bias* is that firm has a knowledge of w_{it} at the time it makes input choices and consequently bases its choice of production inputs on its prior beliefs about their productivity (Olley and Pakes, 1996; Ackelberg *et al.*, 2006) Logically, positive productivity shock will lead to the increase in the use of variable inputs such as materials and labour, which would result in an upward bias on the coefficients of labour and materials (De Loecker, 2007). Moreover, Levison and Petrin (2003) show that, in case of a two-input production function, where labour is the only free input and capital is quasi-fixed, a positive correlation between labour and capital would lead to a downward bias in the capital coefficient. The biases in estimated factor elasticities will further result in biased TFP estimates. It is hard to determine the direction of the bias, since the biases are opposite for the elasticities of fixed and variable inputs. Potentially, for the firms that rely heavily on the use of variable inputs TFP will be biased downwards; and for the firms that make extensive use of capital – upwards.

A number of methods dealing with *simultaneity* problem have been developed over time. Traditional methods include fixed effects and instrumental variables (Griliches and Mairesse, 1995); while more recent techniques include Olley and Pakes (1996); Blundell ad Bond (1999) and Levinson and Petrin (2003). The advantages and drawbacks of these methodologies will be discussed later in section 3.5.2.

[23] Harris (2005); Van Beveren (2007); Ackelberg *et al.* (2010) provide a detailed discussion of the methodological issues related the estimation of TFP. Please refer to their works for a more detailed discussion.

3.5.1.2 Endogeneity of attrition or selection bias

The problem of selection bias was first discussed in the work of Wedervang (1965) and has been given considerable attention since then. However, the first estimation algorithm which explicitly accounted for selection bias was introduced by Olley and Pakes only in 1996. Before then, the TFP was estimated by constructing a balanced panel of continuing firms, while all the firms that entered or exited the sample during the observed period were excluded from the analysis. A number of theoretical models (Jovanovic, 1982; Hopenhayn, 1992) have shown that firm's exit decisions are highly correlated with its productivity. Moreover, in the empirical study based on the sample of Spanish manufacturing firms Farinas and Ruano (2005) found that firm's exit patterns are highly correlated with their productivity differences, leading to the conclusion that higher productivity would lower the probability of exit on the firm level.

And even if we use an unbalanced panel that implicitly accounts for firms' entry and exit, selection bias will still remain until exit decision is explicitly taken into account. According to Ackelberg *et al* (2007) all the firms have prior knowledge of their productivity level w_{it} before the exit actually takes place. This in turn will generate negative correlation between firm-level unobserved productivity and its capital stock, because firms with higher capital stock will be able to operate with lower productivity as compared to the firms with a lower capital stock. In this case the selection bias will introduce a downward bias in the capital coefficient due to the negative correlation between unobserved productivity (w_{it}) and capital stock (k_{it}). Thus the estimates of TFP obtained via traditional approach (using equation (3.2)) without accounting for the firm's exit decision will be biased upwards. Finally, using a balanced panel of continuing firms to calculate TFP will result in a further upward bias of the TFP estimates. This is due to the fact that exiting firms are less productive than continuing firms and ignoring them might lead to lower factor elasticities and thus higher TFP estimates. The same logic may be applied when considering firm's exporting decision. Firm's decision to export is also correlated to its productivity and has to be explicitly taken into account when trying to obtain unbiased TFP estimates. Logially, firms that enter global market are more productive than their domestic counterparts and ignoring them will result in a downward bias in the TFP estimates due to the positive correlation between decision to export and firm's productivity.

A brief overview of recent econometric techniques that tackle the selectivity issue will be presented in section 3.5.2.

3.5.1.3 Omitted price bias

Due to the fact that firm-level prices are rarely available to researchers, majority of empirical studies use industry-level price indices to deflate firm-level sales and input costs, which are further used as proxies for the output and input quantities in the estimation of production function (De Loecker, 2007). However, in the presence of correlation between firm-level prices and its input choice this technique will result in biased input coefficients. Logically, assuming standard demand supply setup, firm's inputs and price should be negatively correlated, thus using industry-level prices as proxies for the firm-level prices will result in a downward bias in the coefficients for materials and labour (Van Beveren, 2010). The *omitted output price* bias can be avoided by using quantities of output instead of deflated values, which was done by Dune and Roberts (1992), Eslava *et al.* (2004), Foster *et al.* (2008), Jaumandreu and Mairesse (2004). Alternatively Kletter and Griliches (1996) and De Loecker (2007) suggested explicitly including the demand for output into the system, which would allow one to solve for firm-level prices.

The size of the omitted output price bias was estimated by Foster et al. (2008) on the basis of the dataset of Colombian manufacturing firms. The authors estimated TFP differences obtained using firm-level and industry-level output prices. The empirical findings showed that the use of the industry-level output prices to deflate firm-level sales leads to significant under-estimation of TFP, with the bias being more pronounced in case of young firms that usually charge lower prices for their products.

Moreover, since input prices also tend to be firm-specific due to the imperfect competition in the input markets, the use of industry-level prices to deflate the values of capital and material costs will lead to the *omitted input price* bias, which is opposite to the *omitted output price* bias. Thus, in case a firm is able to acquire input at lower-than-market prices, using industry-level prices to deflate the values of inputs would lead to an upward bias in the firm-lever TFP estimates and vice versa. The problem can be solved by using the information on actual input prices and quantities (Eslava et al. (2004) and Ornaghi (2006)). However, a formal solution to the omitted input price bias without making use of the firm-level input price data has not yet been found.

3.5.1.4 Multi-product firms

The last bias that can arise when measuring TFP on the firm level is related to multi-product firms. In particular in order to obtain an unbiased and consistent TFP estimates for a multi-product firm, one needs all the information on the input, output and prices on the *product-level* (Van Beveren, 2007). Such detailed data is rarely available, so Bernard *et al* (2009) suggested that problem can be partially resolved by gathering firms into groups by products to obtain single-product factor elasticities and consequently TFP estimates. However, such approach might lead to under-estimation of TFP because it does not take into account positive synergies of multiple products production. Alternatively the issue can be dealt with by allowing for the variation in the factors of production function for the firms producing different product mix (Bernard *et al.,* 2009).

3.5.2. Different TFP estimation methods

In order to address methodological issues discussed in the previous section a number of techniques have been developed to help deal with the problems of simultaneity and selection bias.

3.5.2.1 Fixed Effect Estimator

One of the traditional methods that allows one to overcome problems of simultaneity and selection bias is fixed-effects estimator. In case we assume that unobserved productivity w_{it} is constant over time, and varies only across firms (within-firm variation), we can rule out simultaneity problem discussed earlier (Ackelberg *et al,* 2007). Also, in case firms' exit decisions are determined by the firm specific productivity component w_{it} and not by the random component ε_{it}, then fixed effect estimator also allows one to overcome the selection bias, caused by the endogeneity of firm's exit decision (Pavcnik, 2002). However, in practice fixed-effects estimator is not so efficient, i. e. it results in extremely low estimates of the capital coefficient. Also, as shown by Olley and Pakes (1996), applying fixed-effect estimator on balanced and unbalanced panel results in two completely different sets of coefficients' estimates, which means that fixed-effect does not correct for selection bias caused by endogenous entry/exit. Also one of the requirements of the fixed-effects estimators is a strict exogeneity of inputs conditional on firms' heterogeneity (Wooldridge, 2009). This means that firms cannot change their production inputs' choice in response to productivity shocks, which is a very unrealistic scenario.

3.5.2.2 Instrumental variables (IV) and GMM estimation

Another way to overcome the endogeneity of inputs in the production function would be to use instruments for the endogenous variables. An attractive feature of IV method is that it does not require strict exogeneity of regressors to get consistent estimates

(Wooldrige, 2009). According to Greene (2008) IV method would result in the consistent estimates if (1) IVs are correlated with endogenous regressors; (2) IVs do not enter production function directly; (3) IVs are not correlated with error term. Suggested instruments for the production function inputs include: output/input prices; variables that shift the demand for output or the supply of inputs (Ackelberg et al., 2007); and lagged levels of inputs.

All the three sets of instruments have certain drawbacks worth mentioning. First, input and output prices serve as good instruments only in case the firm operate in a perfectly competitive market, which is rarely the case. In case a firm has some market power, its prices will reflect at least to some extent the quantities of inputs used for production and its productivity, which makes them endogenous. The use of demand/supply shifters (such as exogenous shocks on labour and capital markets) as instruments has not been popular, which is most likely related to the fact that it is hard to find suitable instruments of this kind for different inputs (Van Beveren, 2010). In theory such instruments should work better as IVs than input/output prices even in case the firm operates under imperfect competition. However, even in this case IV approach would only account for the endogeneity of production inputs and would not eliminate selection bias caused by the endogenous exit decisions (Ackelberg *et al*, 2007). Finally using lagged input levels as instruments for the changes in production inputs (after first-differencing production function) often leads to an under-estimated and often insignificant capital coefficient.

Alternatively, Blundell and Bond (1998, 2000)[24] have suggested a dynamic panel approach (extended GMM estimator). The authors argued that bad performance of the standard IV approach was caused by the use of weak instruments and suggested using lagged first-differences of the production inputs as instruments when estimating level equations of the production function. They have also allowed for an autoregressive component in ω_{it}.

3.5.2.3 Olley-Pakes (OP) and Levinsohn-Petrin (LP) Estimation Techniques

In order to overcome simultaneity and selection problem Olley and Pakes (1996) developed a semi-parametric estimator, which overcomes the simultaneity problem by

[24] Other work in this area includes papers by Chamberlain (1982), Anderson and Hsiao (1982), Arellano and Bond (1991), Arellano and Bover (1995).

using firm's investment decision to proxy for unobserved productivity shock (ω_{it}) and eliminates the selection bias by explicitly introducing exit decision into the model[25].

The OP algorithm was further developed by Levinsohn and Petrin (2003) who relied on intermediate inputs to proxy for unobserved productivity (ω_{it}). Main assumptions of the LP algorithm differ from those of the OP in two main respects. First, instead of relying on investment decision to proxy for unobserved productivity LP relies on intermediate inputs as a proxy. Furthermore, the monotonicity condition for the OP technique requires investment to be strictly increasing in productivity, which implies that only observations with positive investment can be retained in the first stage of the estimation process. This requirement leads to a significant data loss and subsequent reduction in the overall estimation efficiency. Moreover, zero investment in a significant number of cases casts doubts on the validity of the monotonicity condition. Instead, LP technique uses intermediate inputs rather than investment as a proxy for unobserved productivity. This in turn requires good quality data on intermediate inputs. However, since firms typically report positive use of materials in each period, the technique makes it possible to retain most of the observations. This also implies that the monotonicity condition is more likely to hold. The second difference between these two techniques is the selection bias correction. The OP technique allows for both an unbalanced panel and an incorporation of the survival probability in the second stage of the estimation. However, the LP technique does not incorporate the survival probability in the second stage, because the efficiency gains of this in the final results proved to be very small in case unbalanced panel is used[26]. In all other aspects estimation of the production function proceeds in a similar way for both OP and LP algorithms. When instead of value-added (or gross output) one wants to estimate revenue production function, LP algorithm would require using GMM estimation instead of NLLS in the second stage[27].

3.5.2.4 Key Assumption of the OP and LP Techniques

Both OP and LP semi-parametric algorithms presented above require several key structural assumptions to achieve consistency of the estimates. Consider the following Cobb-Douglas production function for the OP estimator:

$$y_{it} = \alpha_0 + \alpha_E l_{it} + \alpha_K k_{it} + \omega_{it} + \varepsilon_{it} \tag{3.5}$$

[25] Technical aspects are covered in detail in Ericson and Pakes (1995) and Olley and Pkaes (1996)

[26] For further details please refer to Levinson and Petrin (2003).

[27] Petrin *et al.* (2003) have developed a Stata program that applies LP using both the NLLS and GMM estimator depending on the production function under study.

And for the LP estimator:

$$y_{it} = \alpha_0 + \alpha_E l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + \omega_{it} + \varepsilon_{it} \tag{3.6}$$

In equations (3.5) and (3.6) *y, l, m* and *k* stand for the logarithms of output, employment, intermediate inputs and capital stock in firm *i* at time *t*. ω_{it}, as discussed earlier, is a productivity shock observed by the firm but not by the econometrician.

First, unobserved firm-level productivity (ω_{it}) should follow first-order Markov process and must be independent of any decision variables of the firm, such as investment and export decisions in the current context (Harris, 2010)[28]. Second, ω_{it} should be the only unobservable state variable to enter investment demand function ((3.7) in case of OP) or input demand function ((3.8) in case of LP). This requirement ensures the invertability of investment (for OP) or input (for LP) demand function, otherwise it is not possible to invert out ω_{it} and eliminate endogeneity. Third, both algorithms require investment (or inputs in case of LP) to be strictly increasing function of the firm's productivity, conditional on other state variables. Thus, in case of OP we have:

$$i_{it} = f_t(\omega_{it,} k_{it}) \tag{3.7}$$

In case of LP we have:

$$m_{it} = f_t(\omega_{it,} k_{it}) \tag{3.8}$$

This assumption is made to ensure the invertability of the investment demand (input demand) function. Now we can use (3.7) and (3.8) to obtain:

$$\omega_{it} = f_t^{-1}(i_{it}, k_{it}) \tag{3.9}$$

and

$$\omega_{it} = f_t^{-1}(m_{it}, k_{it}) \tag{3.10}$$

Then we can insert (3.9) and (3.10) into (3.5) and (3.6) respectively to control for unobserved productivity, which gives us:

$$y_{it} = \alpha_0 + \alpha_E l_{it} + \alpha_K k_{it} + f_t^{-1}(i_{it}, k_{it}) + \varepsilon_{it} \tag{3.11}$$

and

$$y_{it} = \alpha_0 + \alpha_E l_{it} + \alpha_M m_{it} + \alpha_K k_{it} + f_t^{-1}(m_{it}, k_{it}) + \varepsilon_{it} \tag{3.12}$$

[28] Discussion is based on Harris (2005, 2010) and Ackelberg *et al.* (2006)

Fourth, in case one uses industry-level prices to deflate values of inputs and output a model implicitly assumes that all the firms in the industry operate on the same input/output prices[29]. Fifth, in OP labour is assumed to have no dynamic implications. Otherwise it will become a part of the investment demand function, which would make an identification of the labour coefficient in the first stage impossible. In LP labour can be a dynamic input. However, in such case the estimation algorithm will have to be adjusted to include labour (of the $(t-1)$ period) into the intermediate input demand function (in period *t*). Also, in case of LP l_{it} and m_{it} must be perfectly variable inputs, i. e. they have to be chosen simultaneously with ω_{it}. Finally, capital k_{it} has to be decided exactly at $(t-1)$ (for OP); and exactly or prior to $(t-1)$ (for LP). In case k_{it} is decided any later than $(t-1)$ it would be no longer orthogonal to the productivity error term ε_{it} ($E(k_{it} \mid \omega_{it}) \neq 0$), which would violate the moment condition. Also, in case of OP, if k_{it} would be chosen prior to $(t-1)$ than we cannot use $(t-1)$ to invert ω_{it} and won't be able to complete the first step of the algorithm. This assumption excludes the possibility of hiring capital assets or any other incremental additions to capital during *t* (Harris, 2010).

3.5.2.5 OP and LP Critique

Given the assumptions described in the previous section both OP and LP should be able to provide unbiased consistent estimates of the production function. However, as discussed in Ackelberg et al. (2006) and Harris (2010), even if all the assumptions hold, both methods still suffer from significant identification issues. Both algorithms aim to uncover labour coefficient (l_{it}) in the first stage. This requires estimating equations (3.11) and (3.12) with a non-parametric composite terms $\alpha_K k_{it} + f_t^{-1}(i_{it}, k_{it})$ and $\alpha_K k_{it} + f_t^{-1}(m_{it}, k_{it})$ correspondingly, which includes non-identified terms i_{it} and k_{it} in case of OP (k_{it} and m_{it} in case of LP). Thus, in order to estimate (3.11) $\alpha_k k_{it} + f_t^{-1}(i_{it}, k_{it})$ is replaced by the unknown polynomial of the three variables included in the term. As discussed by Ackelberg at el. (2006), due to the fact that parameter l_{it} is collinear to the non parametric composite term $\alpha_k k_{it} + f_t^{-1}(i_{it}, k_{it})$ it is not possible to idenfy α_l and α_k. In fact, Ackelberg *et al.* point out that collinearity issues are more severe in case of LP estimator than in the case of OP estimator.

[29] Please ferer to Olley and Pakes (1996) for a detailed description of the estimation procedure.

Moreover, authors point out that OP and LP estimators do not allow for fixed effects, which is a significant drawback since they tend to be highly correlated with firm's productivity. Also, it is assumed that investment (or inputs in case of LP) should be monotonically increasing in ω_{it}, and ω_{it} should be the only unobservable variable in the investment (input) demand function, which limits the presence of any measurement errors in *i*, *k* and *m* respectively. In reality both OP and LP algorithms would produce actual numerical estimates α_l, α_k, α_m. However, according to Ackelberg *et al.* (2006), these estimates would not be consistent, unless certain additional requirements for the data generation process hold[30]. Instead, dynamic panel data estimation techniques allow for the use of fixed effects and do not impose strict ω_{it} - monotonicity condition on investment variable. Moreover, dynamic panel data estimator allows ε_{it} to be correlated with factor inputs in the periods following *t*, while semi-parametric estimators require zero correlation between ε_{it} and factor inputs at all *t*. Finally, GMM estimation does not require labour to be non-dynamic input and does not impose any restriction on the timing of investment (Harris, 2010). In the next section we implement different estimation techniques and compare our estimates of the production function coefficients.

3.5.3. Estimation of the Production Function Coefficients

In this section we implemented several estimation techniques to obtain output elasticities and estimates of the firm-level TFP. Table 3.5 reports the production function coefficients obtained using the OP, LP, Fixed Effects and *IV* fixed effects (FE2SLS) estimators[31]. All reported estimates are obtained for the unbalanced panel of firms, for the period 2000-2005.

[30] This is true only in case of the OP estimator. As shown by Ackelberg at al. (2006), in case of LP the issue of collinearity cannot be resolved. Please refer to their paper for a more detailed explanation.

[31] The results of the FE, OP, LP, FE2SLS for the 19 industry groups are reported in Appendices 3.11, 3.12, 3.13 and 3.14.

Table 3.5. Production function coefficients: Different estimation methods

19 Sub-sectors	Fixed Effects	Olley-Pakes	Levinsohn-Petrin	FE2SLS
α_l	.616*** (.0039)	.568*** (.0071)	.564*** (.00594)	.508*** (.0169)
α_m	.271*** (.0022)	.326*** (.0042)	.326*** (.0051)	.370*** (.0139)
α_k	.111*** (.0025)	.0737*** (.0281)	.0109*** (.0103)	.282*** (.0100)

Note: ***- significant at 1% level; **- significant at 5% level; *- significant at 10% level

All the estimators presented in the Table 3.5 are obtained using STATA 11 routines. In particular, I used *xtreg* command for the fixed effects estimator. IV Fixed effects estimator was implemented using *xtivreg* command. In order to account for endogeneity of inputs I used lagged values endogenous variables[32] as well as *age*, *region* and a dummy for the firm's *intangible assets*[33] as three additional instruments. According to Harris and Li (2007, 2009), such variables as *age, region* and *intangible assets* of the firm can help address problems of *inefficiency, self-selection* and *omitted variable bias*, that usually arise when a two-stage approach of testing TFP determinants is implemented[34]. Both *age* and *intangible assets* are highly significant determinants of the firm's export decision, but appear to be insignificant, when included into the production function.

The OP estimation was implemented following practical suggestions provided in Arnold (2005). Finally the LP estimator was implemented using *levpet* command following Petrin *et al*. (2003).

It should be noted, that despite the fact, that all estimated output elasticities are significant on the aggregate level, the estimated output elasticities on the industry level (Appendices 3.11, 3.12, 3.13 and 3.14) show insignificant estimates of the capital coefficient in a number of industries for all four chosen estimation algorithms. This might be the result of a measurement error of capital. However, insignificant capital coefficient estimates might also arise due to specification issues, present in each of the techniques implemented here[35]. For example, fixed effects estimator only addresses simultaneity issue, with a requirement for strict exogeneity of production function

[32] I used lagged levels of *l, m, k.*

[33] Dummy equals 1 if a firm possesses positive intangible assets.

[34] Please refer to section 3.5.1 for detailed discussion of methodological issues related to the standard two-stage approach of testing TFP determinants.

[35] Please refer to section 3.5.2 for detailed discussion of the TFP estimation issues

inputs. However, it does not resolve selection bias (in case of endogenous exit decisions) as well input price bias. According to Van Beveren (2010) IV fixed effects estimator should perform better, as it does not require strict exogeneity of inputs in the production function to get consistent estimates. However, IV fixed effects estimator only resolves problems of endogenous production function inputs, and does not resolve selection bias caused by endogenous exit decisions. In practice both fixed effect and IV fixed effect estimators would result in low and sometimes insignificant estimates of capital coefficient (Van Beveren, 2010), which we can observe in this case. As far as OP and LP estimators are concerned apart from a number of drawbacks discussed in section 3.5.2.5, which cast some doubts on the validity of these techniques, both techniques do not allow for fixed effects, which is a significant drawback in the framework of current analysis.

Taking into account methodological issues, attributed to different estimation algorithms, our preferred estimation method is IV fixed effect estimator, as it does not require exogenous inputs for consistent estimation, and, more importantly, ensures consistency in the use of fixed effects in the second stage of the analysis.

In the rest of the chapter I will use the estimates of the TFP obtained at this stage to define TFP determinants: in particular - to study export-productivity linkages. This strategy implies the use of the two-stage approach. However, since the omitted variable problem might have not been entirely resolved at this stage, there is s probability of getting inefficient[36] and downward-biased estimates in the second stage of the analysis (Wang and Schmidt, 2002). One of the possible solutions to this problem would be to use the DPD methods (i. e. system-GMM approach) as per Harris and Li (2007), which should allow for the use of fixed effects, as well as for endogenous inputs[37]. It should be noted, however, that Van Bevern (2010) using a simple empirical example with the data for the food and beverages sector in Belgium showed that estimates of the TFP measure obtained through different estimation methods are highly correlated and lead to very similar results, when used to investigate effects of different policy measures. Thus, the author concludes that TFP estimates obtained through different estimation methods (OLS, GMM and semi-parametric techniques) still lead to similar conclusions in the second-stage of the analysis, when the impact of various TFP determinants is explored.

We proceed further to estimating exporting-productivity linkages using the TFP estimates obtained in the current section.

[36] Potentially inconsistent standard errors and inconsistent *t*-values (Harris, 2005)

[37] This technique is left for further consideration and use.

3.6. Exporting-Productivity Relationship Estimation

3.6.1. Theoretical background

As discussed in the previous section we can now use our firm-level TFP estimates to study the effect of various TFP determinants. In particular, our interest lies in exploring the effect of exporting on productivity.

Estimating exporting-productivity links on the micro level may be complicated by several methodological difficulties, such as issues as *endogeneity* and *selection bias*. Selection bias occurs because firms that become exporters may be systematically different from their domestic counterparts in certain unobservable characteristics which make them superior to non-exporting firms even if they remained purely domestic, thus affecting their decision to engage into exporting. Hence a simple comparison of average productivities between exporters and non-exporters may result in biased estimates of the treatment effect[38].

There are several standard techniques that account for the sample selection. The first approach that deals with selection bias is *instrumental variables* (IV) estimation. This method requires finding appropriate instrument variables that affect the treatment decision (decision to export) but do not directly influence the outcome (TFP). In this case such variables can be used to overcome the problem of self-selection. In other words instrumental variable affects the outcome (TFP) indirectly through its impact on the treatment participation (exporting). However, it does not enter the into the outcome equation directly. Hence, such a variable can be used to eliminate the problem of self-selection and identify the causal impact of treatment participation on the outcome. The main problem with the IV approach is availability of appropriate instruments, which sometimes might be limited due to data issues and economic mechanisms that determine the relationship between treatment and outcome (Angrist and Krueger, 2001). Second problem with IV approach is related to heterogeneity of treatment effects. In such case, instead of estimating an average impact of treatment effect on treated, the IV model will estimate a Local Average Treatment Effect (LATE). In which case, we will get estimates of the local impact of the instrument variable on those participants who change their participation status in response to a change in the instrument variable value (Angrist and Imbens, 1995; Heckman 2000). This might results in different impacts for

[38] See Heckman and Navarro-Lozano (2004) for a formal discussion.

different instruments instead of the homogenous treatment effect, especially in cases when the data is characterised by a high degree of heterogeneity.

The second approach used to deal with self-selection bias is a standard Heckman two-stage (or control function) procedure, which is closely linked to the IV approach. First, predicted values of the probability of exporting are obtained with the help of the firs-stage probit (logit) estimator. These predicted values are further used to calculate inverse Mills ratios (sample selectivity correction terms), which are included in the second-stage equation to control for correlation between firm's productivity and its export decision. One of the limitations of Heckman procedure is the requirement for the *correct* specification of the first-stage nonlinear regression. If probit (logit) is used to generate fitted values that are further plugged into the second-stage linear regression the estimates of the second-stage will only be consistent in case, when the specification of the first-stage nonlinear model is perfectly *correct*, which raises the risk of specification error (Angrist and Krueger, 2001). Also, as noted by Puhani (2000), Heckman procedure can often lead to non-robust results due to collinearity problems.

At last, one of the most commonly used methods to tackle self-selection is matching. This technique implies matching every exporting firm with a domestically oriented firm that possesses very similar characteristics. Thus, this technique allows us to construct a matched sample of non-exporting firms with the same observable characteristics that influence their productivity, hence the probability of exporting. This matched sample provides us with missing information on the outcomes which exporters would have experienced if they remained purely domestic. One methodological difficulty of matching is that some differences in unobservable characteristics may still be present between the treatment and control group. However, since matching is done on a common set of variables (the ones that impact the outcome and the ones that impact on participation in the treatment); this method assumes that any selection of unobservables has no influence on the outcomes in the absence of treatment (Harris, 2005). Furthermore, as discussed in Heckman and Navarro-lozano (2004), excess information about treatment participation might sometimes lead to perfect prediction of treatment probability, which will make it impossible to implement matching on a common set of variables. Another problem of this approach is the requirement for a large dataset which includes all variables that impact selection into treatment as well as outcomes (Heckman and Navarro-Lozano, 2004; Harris, 2005). Moreover, treated plants, for which there is no match in the untreated sub-group are usually dropped, which can significantly reduce the size of the treated sub-group in the analysis. Thus, matching works only in case when there is enough common support between treated and untreated (control) sub-group. Finally, one of the assumptions of matching is that the effect for the average treatment participant equals to the effect for the marginal participant[39], which is an unattractive implication according to Heckman and Navarro-Lozano (2004).

Taking into account relative strengths and drawbacks of the methods discussed above, I chose to implement *propensity score matching approach* to estimate the impact of engagement into international markets on productivity using the representative dataset of Ukrainian firms. First of all, relatively generous dataset provides enough common support between treatment and control sub-groups. Also methodological issues present in Heckman procedure cast some doubts on the validity of the estimates obtained via Heckman approach. As far as IV estimation is concerned, previously used instruments in this case include age of the firm and its intangible assets (i. e. investment in R&D). However, a number of studies have shown that investment in the knowledge creating activities is correlated with firm's productivity. Furthermore, some theoretical models argue that age is directly linked to a firm's productivity, and several empirical studies have provided evidence in favour of this hypothesis. Also GMM estimation procedure used for IV approach requires several lags, which is a significant drawback in the current case owing to the comparatively short time period of the dataset in use (2000-2005)[40].

3.6.2. Estimation Methodology

In the first stage, I estimate the following probit model to identify the probability of becoming exporter (i. e. the propensity score):

$$\begin{gathered} P(Export_{it} = 1) = \\ \phi(\ln TFP_{it-1}, Age_{it-1}, Intang_{it-1}, \ln Emp_{it-1}, (\ln Emp_{it-1})^2, Industry_{it}, \mathrm{Re}\,gion_{it}, Year_t) \end{gathered} \tag{3.13}$$

Where *Export* is coded 1 if the firm enters export market in the year t[41]; *TFP* is the estimate of the Total Factor Productivity obtained in the first stage; *Age* is the age of the firm (number of times/years in operation); *Intang* is coded 1 if the firm has nonzero

[39] In other words the effect of treatment on the treated is the same as unconditional treatment effect.
[40] The system GMM approach is left for further consideration.
[41] In order to concentrate on entrants I retain only those firms that start exporting at any time during 2000-2005 (i. e. in years 2001-2005) and remain exporters until the end of the observed time period.

intangible assets[42] (the average annual percent of firms possessing positive intangible assets equals 14.8%; we assume that the rest of the sample does not possess any intangible assets by setting the rest of the observations to zero), *Emp* represents the number of employees; and *Industry*, *Region and Year* are dummy variables indicating each industry subgroup, regional attribute and year. To increase the quality of the estimation, we estimate the model separately for each of the 19 sub-sectors, which also allow us to exclude industry specific dummies from the regression.

It is important to note that in the current context my preferred estimator for the probability of exporting is standard probit instead of the fixed-effects probit estimator. Despite the fact that fixed-effects probit estimator takes into account unobserved firm-specific effects treating them as parameters alongside with other parameters of the model; in practice it is computationally difficult. Furthermore, estimation of the fixed-effects together with other model parameters introduces *incidental parameter problem*, which leads to inconsistent estimates of the model parameters, provided *T* (time period) is fixed and number of observations is relatively large ($N \rightarrow \infty$) . As noted by Lancaster (2000), solutions for the *incidental parameter problem* are developed on a case by case basis and typically involve differencing, conditioning, or use of instrumental variables[43].

In the next step, we use the propensity scores (probability of exporting) to construct the matched sample (Girma *et al.*, 2004; Harris and Li, 2007). In order to increase the quality of matching, we require potential matches to be in the same 2-digit NACE industry as their exporting counterparts[44]. We construct the matched comparison group using the "nearest-neighbour" approach; i.e. we choose those non-exporters that have predicted probability of entering international markets closest to that of the exporting firms. Matching is done with replacement, which means that if a non-exporting firm appears to be the closest match for more than one exporting firm, this firm can be used as control as many times as necessary.

Figure 3.3 shows the differences in the predicted probability of exporting (*_pscore*) between exporters and matched non-exporters (Summary statistics for *_pscore* is

[42] The non-monetary assets may refer to patents, copyrights, trademarks, innovative activities, advertising, goodwill, brand recognition and similar intangible assets. Since there is considerable controversy about what should be included and how to measure intangible assets, I follow Harris and Li (2007) and use a dummy variable to measure intangible assets.

[43] Please refer to Lancaster (2000), Fernandez-Val (2007) for further discussion of the issue.

[44] My attempts to impose the requirement on the potential estimates to be in the same region as their exporting counterpart have led to significant data loss.

provided in Table 3.6). Most of the differences in the probability of exporting do not exceed 0.008, which means that there are enough close matches for all treated (entrants into exporting) firms. However, the level (0.008) is set as a calliper which defines the interval of common support, and any matched pairs with a difference in the exporting probabilities greater than this threshold are eliminated. A relatively small size of the calliper increases matching quality, decreasing the size of the sample. However, this procedure excludes the possibility of obtaining spurious results drawn by the outliers that do not have good matches (Brown, Earle, 2008).

Having obtained the matched sample, we test the learning-by-exporting hypothesis by estimating the following fixed effect panel model:

$$\ln TFP_{it} - \ln TFP_{jt} = \phi(Export_{it}) \tag{3.14}$$

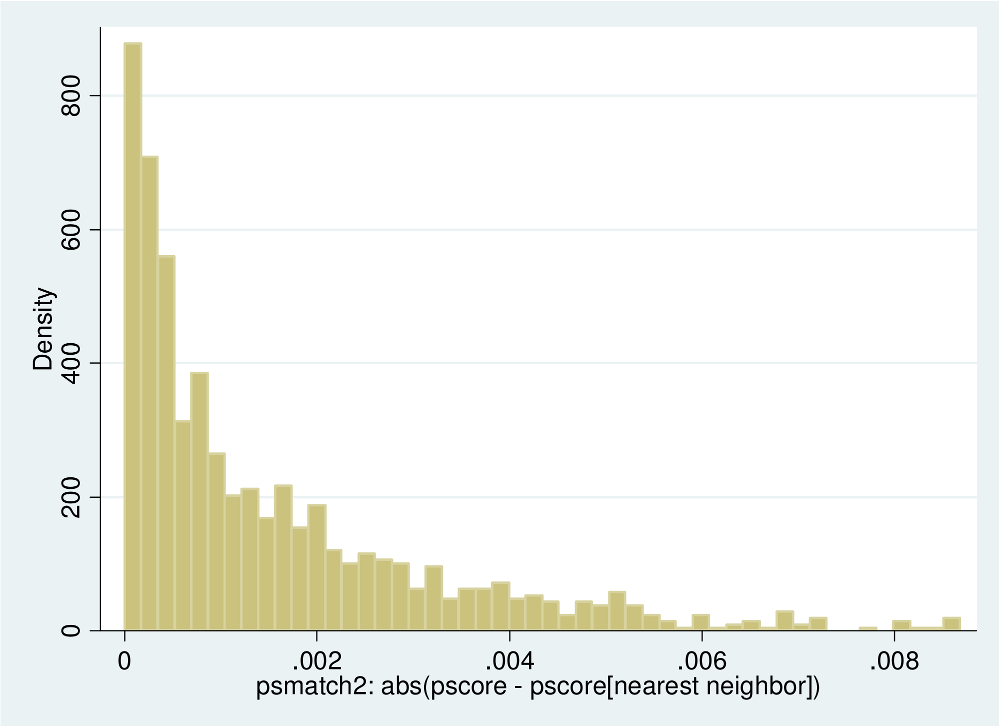
where the dependent variable is the difference between the TFP estimates of the treated and control firm. *Export* is a set of dummy variables indicating export status. The set includes: $Year\_before_{it}$ coded 1 in the year prior to the start of exporting; $entry\_year_{it}$, $year\_after_{it}$, $two\_years\_after_{it}$ – dummies reflecting correspondingly the entry-into-exporting year, one year after the entry, and two and more years after engaging into exporting activity. Note that the use of the fixed effects estimator at this stage is consistent with the use of the IV fixed effects estimator, used in section 3.5.3 to obtain TFP estimates.

Table 3.6. Summary Statistics of the difference in the probability of exporting between treated and matched firms

Variable	Min	Max	St Deviation	Mean
_pdif	8.94e-08	.0086817	.0016612	.001526

Note: _pdif = (pscore - pscore[nearest neighbour])

Figure 3.3. Difference in probability of exporting between treated and matched firms, 19 sub-sectors



Note: Own calculations

3.6.3. Results

We start with estimating Equation (3.13) using the probit model to get the propensity score, i.e. the probability of exporting that will be used in the matching procedure at a later stage. The results of the 19 industry groups are reported in Table 3.7. Overall, the results of the estimation show that size of the firm matters for exporting: i.e. larger firms are more likely to engage into exporting activity. Also firms with higher TFP in period *t-1* are more likely to enter export markets in period *t*. Firms with positive intangible assets are more likely to enter export markets. Finally, in majority of the industries age of a firm increases the probability of exporting. The analysis in line with the majority of previous studies shows that there was a strong self-selection into export markets among Ukrainian firms during 2000-2005, in most of the 19 industry sub-groups examined.

Next I estimate equation (3.14) to test for the "learning-by-exporting" effect associated with a further increase in TFP following entry into the overseas markets. First I employ the propensity score matching procedure to obtain a matched sample of exporters and non-exporters, concentrating on export market entrants, and then use this matched sample to estimate equation (3.14). The quality of the matching algorithm is verified by a number of balancing tests[45].

The complete set of results referring to the impact of "learning-by-exporting" performed on the matched sample is presented in the Table 3.8 and Table 3.9. The first specification estimates whether firms which enter export markets for the first time experience significant positive impact of the overseas sales on productivity in the *post-entry* period. The second specification studies the impact of the overseas sales on productivity in each year following entry into the export market: the entry year, post entry year and two and more years after entry.

Both model specifications produce mostly similar results in terms of their significance[46] and show that the learning-by-exporting effect was present in most of the estimated industries during the period 2000-2005. However, in such industries as mining/quarrying of energy producing materials; textile/clothing/leather/fur; rubber/plastic – no significant productivity gains have been observed in the period following entry into international markets in case of the second model specification; while first model specification still shows the presence of the learning-by-exporting effect in these two industries. Finally, the overall estimate for the 19 Ukraine manufacturing and service sectors reveals the presence of a substantial post-entry productivity effect for the firms new to exporting in both model specifications.

The results presented in the current chapter provide a sound support in favour of the self-selection and learning-by-exporting hypothesis. However, the effect is not universal across all estimated industries. In general, our findings are consistent with the previous findings in the area. For example, Harris and Li (2007) using data for UK manufacturing and service sectors found an overall positive boost in TFP for the first time entrants into export markets during the first and the second post-entry years. However, their results for separate sectors show that the post-entry productivity effect is present only in many industries, but not universal. On the other hand, studies that explored developing countries usually found much stronger support in favour of both self-selection and learning-by-exporting effects. One of the reasons for that being that technological differences and hence opportunities for acquiring and adopting new technologies during exporting activity are higher in case when trade occurs between

[45] Please refer to section 3.6.4 for details.
[46] Apart from the two industries: textile/clothing/leather/fur; rubber/plastic

developing and industrialised countries. Some examples include studies by Clerides et al. (1998) for Columbia, Morocco and Mexico; Castellani (2002) - for Italy; Hallward-Driemier (2002) *et al.* - for East Asia; Blalock and Gertler (2004) - for Indonesia; Fernandes and Isgut (2005) - for Colombia; Yasar and Rejesus (2005) – for Turkey.

Table 3.7. Probit model estimation results. Marginal effects.

Industry classification	lnTFP_{t-1}	$lnEmp_{t-1}$	$lnEmp^2_{t-1}$	$Intange_{t-1}$	Age_{t-1}	*Pseudo* R^2	*No. Obs.*	*Non-treated* *Treated*
19 sub sectors	.049*** (.0009)	-.003 (.0048)	.013*** (.0005)	.092*** (.0023)	.006*** (.0008)	0.23	164985	123,826 41,159
1. Agriculture/forestry/fishing	.030* (.017)	.428*** (.069)	.088*** (.008)	.123*** (.029)	.010 (.014)	0.40	2380	1,194 1,186
2. Mining/quarrying of energy producing materials	.104*** (.023)	.103* (.051)	.001 (.005)	.024 (.035)	.116*** (.015)	0.15	1069	704 365
3. Mining/quarrying, except of energy producing materials	.149*** (.021)	.260* (.152)	-.004 (.017)	.046 (.038)	.012 (.014)	0.26	1084	614 470
4. Food/beverages/tobacco	.091*** (.008)	-.028 (.032)	.022*** (.003)	.109*** (.010)	.038*** (.004)	0.18	11725	7,393 4,332
5. Textile/clothing/leather/fur	.212*** (.019)	.036 (.135)	.021* (.011)	.078*** (.020)	.023*** (.008)	0.31	4150	2,241 1,909
6. Wood/wood products (+36)	.017 (.024)	-.027 (.087)	.028*** (.010)	.042 (.034)	.077*** (.011)	0.20	1236	737 499
7. Coke/nuclear/chemical	.056*** (.012)	-.038 (.043)	.017*** (.004)	.078*** (.022)	.028*** (.006)	0.19	1932	1,381 551
8. Rubber/plastic	.144*** (.026)	.225** (.100)	.049*** (.011)	.189*** (.029)	.030*** (.010)	0.26	1318	751 567
9. Non-metallic minerals	.035*** (.014)	-.347*** (.054)	.061*** (.005)	.118*** (.019)	.027*** (.006)	0.22	3835	2,345 1,490
10. Basic/fabricated metals	.112*** (.017)	.158*** (.053)	.038*** (.006)	.142*** (.019)	.028*** (.005)	0.21	3277	1,853 1,424
11. Machinery and equipment	.037*** (.010)	-.262*** (.038)	.051*** (.004)	.129*** (.014)	.053*** (.004)	0.24	6276	2,934 3,342

Industry classification	lnTFP_{t-1}	$lnEmp_{t-1}$	$lnEmp_{t-1}$	$Intange_{t-1}$	Age_{t-1}	R^2	*Non-exporters Exporters*	*Non-treated Treated*
12. Electrical and optical equipment	-.004 (.010)	-.125*** (.045)	.028*** (.005)	.169*** (.018)	.034*** (.006)	0.17	3322	1,242 2,080
13. Transport equipment	.124*** (.020)	-.024 (.046)	.012*** (.004)	.077*** (.025)	.025*** (.008)	0.21	1510	1,077 433
14. Manufacturing n.e.c.	.104 (.012)	.115 (.056)	.008 (.006)	.121 (.021)	.019 (.007)	0.24	2694	1,396 1,298
15. Wholesale trade	.015*** (.004)	-.013 (.027)	.011*** (.003)	.083*** (.011)	.004 (.003)	0.27	4784	3,956 828
16. Retail trade	.022*** (.001)	-.033*** (.010)	.013*** (.001)	.112*** (.005)	.022*** (.001)	0.38	30638	20,798 9,840
17. Repair of motor vehicles	.017*** (.001)	.018*** (.004)	.001** (.000)	.021*** (.002)	.008*** (.000)	0.15	26316	25,074 1,242
18. Transport/transport services/post	.084*** (.003)	.036*** (.009)	.002** (.000)	.038*** (.006)	.006*** (.001)	0.18	13814	11,819 1,995
19. Real estate/renting/business activities	.062*** (.002)	.001 (.009)	.005*** (.001)	.053*** (.005)	.005*** (.001)	0.10	20755	17,734 3,021

Note: Dependent variable: difference between treated and control TFP estimates. Robust standard errors in parentheses; ***- significant at 1% level; **- significant at 5% level; *- significant at 10% level. The model also includes *Industry* (on the aggregate level), *Region* and *Year* dummies

Table 3.8. Impact of exporting activity on TFP, matched sample, entrants versus non-exporters

	Industry classification	*Post Entry*	*No. Obs.* *No. Groups*	R^2
	19 sub sectors	.588*** (.012)	148,985 51,502	0.17
1.	Agriculture/forestry/fishing	.496*** (.095)	1,621 612	0.16
2.	Mining/quarrying of energy producing materials	.118 (.304)	926 366	0.10
3.	Mining/quarrying, except of energy producing materials	.657*** (.143)	642 257	0.19
4.	Food/beverages/tobacco	.394*** (.038)	10,069 3,827	0.10
5.	Textile/clothing/leather/fur	.445*** (.095)	2,652 1,202	0.14
6.	Wood/wood products (+36)	.352*** (.097)	748 433	0.15
7.	Coke/nuclear/chemical	.311*** (.065)	700 321	0.18
8.	Rubber/plastic	.217* (.011)	640 275	0.16
9.	Non-metallic minerals	.202*** (.042)	2,802 1,021	0.22
10.	Basic/fabricated metals	.469*** (.084)	1,836 795	0.15
11.	Machinery and equipment	.286*** (.050)	4,035 1,664	0.12
12.	Electrical and optical equipment	.277*** (.063)	1,699 773	0.16
13.	Transport equipment	.587*** (.124)	529 241	0.18
14.	Manufacturing n.e.c.	.427*** (.080)	1,712 767	0.14
15.	Wholesale trade	1.65*** (.340)	4,114 1,635	0.07
16.	Retail trade	.786*** (.035)	27,002 12,230	0.21
17.	Repair of motor vehicles	.394*** (.099)	25,817 8,702	0.10
18.	Transport/transport services/post	.551*** (.135)	12,429 3,913	0.11
19.	Real estate/renting/business activities	.538*** (.028)	19,376 6,941	0.08

Note: Dependent variable: difference between treated and control TFP estimates. Model also includes region dummies. Standard errors in parentheses; ***- significant at 1% level; **- significant at 5% level; *- significant at 10% level.

Table 3.9. Impact of exporting activity of TFP, matched sample, entrants versus non-exporters: Fixed effects

	Industry classification	*Year before*	*Entry year*	*Year after*	*2 and more Years after*	*No. Of Obs. No of Groups*
	19 sub sectors	-.569*** (.013)	.264*** (.016)	.388*** (.019)	.401*** (.023)	148,985 51,502
1.	Agriculture/forestry/fishing	-.581*** (.120)	.168 (.110)	.229** (.105)	.213** (.114)	1,621 612
2.	Mining/quarrying of energy producing materials	-.293 (.412)	.069 (.455)	.062 (.362)	-.482 (.518)	926 366
3.	Mining/quarrying, except of energy producing materials	-.454*** (.174)	.437** (.231)	.468** (.215)	.318 (.209)	642 257
4.	Food/beverages/tobacco	-.596*** (.049)	.046 (.045)	.115** (.044)	.148*** (.055)	10,069 3,827
5.	Textile/clothing/leather/fur	-.532*** (.120)	.137 (.111)	.109 (.137)	.192 (.138)	2,652 1,202
6.	Wood/wood products (+36)	-.209** (.098)	.121 (.103)	.366** (.187)	.233* (.132)	748 433
7.	Coke/nuclear/chemical	-.416*** (.077)	.152* (.083)	.096 (.087)	.075 (.106)	700 321
8.	Rubber/plastic	-.260*** (.109)	.035 (.135)	.068 (.145)	.239 (.167)	640 275
9.	Non-metallic minerals	-.249*** (.051)	.091* (.052)	.103** (.049)	.080 (.056)	2,802 1,021
10.	Basic/fabricated metals	-.537*** (.076)	.183** (.070)	.204*** (.085)	.259*** (.084)	1,836 795
11.	Machinery and equipment	-.386*** (.051)	.044 (.055)	.154*** (.057)	170** (.079)	4,035 1,664
12.	Electrical and optical equipment	-.350*** (.066)	.135* (.084)	.152 (.103)	.075 (.086)	1,699 773
13.	Transport equipment	-.639*** (.112)	.186 (.112)	.325** (.134)	.317** (.149)	529 241
14.	Manufacturing n.e.c.	-.501*** (.093)	.119 (.092)	.239*** (.097)	.322*** (.089)	1,712 767
15.	Wholesale trade	-.880*** (.309)	1.16*** (.396)	1.24** (.583)	1.29 (.813)	4,114 1,635
16.	Retail trade	-.552*** (.032)	.384*** (.045)	.658*** (.056)	.631*** (.071)	27,002 12,230
17.	Repair of motor vehicles	-1.075*** (.096)	-.090*** (.128)	-.271* (.153)	.066 (.202)	25,817 8,702
18.	Transport/transport services/post	-.752*** (.127)	.190* (.109)	.219 (.168)	.219 (.262)	12,429 3,913
19.	Real estate/renting/business activities	-.546*** (.023)	202*** (.036)	.385*** (.045)	.416*** (.055)	19,376 6,941

Note: Dependent variable: difference between treated and control TFP estimates. Model also includes region dummies. Standard errors in parentheses; ***- significant at 1% level; **- significant at 5% level; *- significant at 10% level. Base category is observations two and more years before engaging into exporting

3.6.4. Balancing Tests

As stated by Rosenbaum and Rubin (1985) and Dehejia and Wahba (2002) in order to ensure the robustness of the propensity score matching method the distribution of the pre-treatment observable characteristics between the treatment and control groups should be balanced. Thus in order to confirm that this balancing condition is fulfilled by the data I follow the recent literature (Dehejia, 2005, Smith and Todd, 2005) and implement a number of balancing tests.

The first balancing test comes from Rosenbaum and Rubin (1985). And it was further implemented by Lechner (1999, 2000), Sianesi (2002) and Smith and Todd (2005). The test estimates the standardized difference (i. e. bias) of all the covariates used in the estimation of the propensity score. According to the test the standardized bias for a variable *X* is calculated as the difference in means between the treated (group A) and the matched comparison group sample (group C) divided by the square root of the average of the variances of *X* in the treatment and comparison group in the original non-matched sample:

$$SDIFF(X) = \frac{100\frac{1}{N}\sum_{i\in A}\left(X_i - \sum_{j\in C} w(p_i, p_j)X_j\right)}{\sqrt{\frac{Var_{i\in A}(X) + Var_{j\in C}(X)}{2}}} \tag{3.15}$$

There is no formal criterion as to the acceptable magnitude of the standardised bias. And Rosenbaum and Rubin (1985) perceive value of 20 as large. In any case, lower value of the standardised difference test ensures better balance between treatment and control group in terms of the tested variable.

Second balancing test that I use was suggested by Smith and Todd (2005). The test evaluates the balancing condition using a regression approach. For each variable included in the model used for propensity score estimation, the test estimates the following regression:

$$X_k = \beta_0 + \sum_{k=1}^{4}\beta_k \widehat{P}(X)^k + \sum_{k=1}^{4}\gamma_k D\widehat{P}(X)^k + \varepsilon \tag{3.16}$$

Where $\widehat{P}(X)$ is the estimated propensity score and *D* is a response variable that indicates the treatment effect. As emphasized by Smith and Todd (2005) if the balancing property is satisfied, *D* would not provide any additional information, which means that γs should be jointly statistically insignificant.

The results of the standardised differences and regression based balancing tests are reported in the Appendix 3.15. The results reflect that implementation of the propensity score matching algorithm results in a substantial bias reduction. Moreover the results of the regression test show that we cannot reject the null hypothesis of the joint insignificance of γs.

3.7. Summary

This chapter presents an attempt to estimate the ways in which exporting might influence a firm's performance and productivity at the micro-level on the basis of the dataset covering main Ukrainian output sectors during the period 2000-2005. In doing so, the current study measures the productivity effect that occurs before entering export markets (self-selection effect) as well as the effect that occurs in the post-entry period (learning-by-exporting effect).

The estimation of self-selection hypothesis is done on the basis of a probit model. The results of the estimation studying the firms which started exporting at any time during the reported period for the 14 Ukraine manufacturing and 5 trade and service sectors go in line with previous findings in the literature on self-selectivity. The results show mainly that firms with higher TFP in the period *t-1* are much more likely to enter export markets in the period *t.* Also age, size and intangible assets of the firm, have significant positive influence of the probability of exporting.

The next part of the analysis studies the productivity effects that occur after the entry into overseas markets (learning-by-exporting effect). The analysis is implemented with the help of the propensity score matching technique to account for the issues of endogeneity and sample selection. The results of the analysis confirm the presence of the learning-by-exporting effect in the majority of industries under study. Some of the industries, however, show no (or very weak) presence of any statistically significant productivity gains in the post-entry period. The quality of the matching procedure is further verified using a number of balancing tests.

In order to reveal common trends behind the results, obtained in favour of the learning-by-exporting hypothesis, it might be useful to compare the results of the current study with previous findings. The paper by Harris and Li (2007) is one of the most recent examples and also one of the best to use for comparison. The authors provide estimates for the 16 separate industries in the UK for the period 1996-2004. Despite the fact that the format of the aggregation across different output sectors is slightly different from the current study, the structure of the analysis still allows us to compare our results with their findings. Table 3.10 compares the results for the long-term learning-by-exporting effect obtained in the current study to those of Harris and Li (2007). The comparison shows that such sectors as food/beverages/tobacco; wood/wood products; coke/nuclear/chemical; machinery and equipment; electrical and optical equipment;

transport equipment; manufacturing n.e.c.; real estate/renting/business activities enjoy productivity gains from exporting both in UK and Ukraine. In the former case the gains in productivity probably arise owing to the economies of scale and better managerial practices learned from foreign partners; while in the latter case the productivity increase might also be caused by the access to new foreign technologies.

Table 3.10 Presence of learning-by-exporting effect in separate industries

NACE code	Industry	Harris and Li	Current Study
(A/B)	Agriculture/forestry/fishing	-	+
(CA)	Mining/quarrying of energy producing materials	N/A	-
(CB)	Mining/quarrying, except of energy producing materials	N/A	+
(DA)	Food/beverages/tobacco	+	+
(DB/DC)	Textile/clothing/leather/fur	+	-/+
(DD)	Wood/wood products (+36)	+	+
(DE)	Paper/printing/publishing	+	N/A
(DF/DG)	Coke/nuclear/chemical	+	+
(DH)	Rubber/plastic	+	-/+
(DI)	Non-metallic minerals	-	+
(DJ)	Basic/fabricated metals	-	+
(DK)	Machinery and equipment	+	+
(DL)	Electrical and optical equipment	+	+
(DM)	Transport equipment	+	+
(DN)	Manufacturing n.e.c.	+	+
(G1)	Wholesale trade	-	+
(G2)	Retail trade	-	+
(G3)	Repair of motor vehicles	-	+
(I)	Transport/transport services/post	-/-/+	+
(K)	Real estate/renting/business activities	+	+
	Total	**+**	**+**

Note: See Harris and Li (2007) for the complete list of their results. "+" - significant learning-by-exporting effect; "-" - insignificant learning-by-exporting effect.

When the estimation is done for all the firms in the dataset, the results of both studies suggest substantial positive post-entry productivity effect for the firms that enter export markets for the first time in one and two years after entry.

Our approach has been widely applied in the literature on the exports-productivity linkages. The main results of the analysis confirm that differences in productivity between exporting and non-exporting firms can be partially attributed to higher productivity levels of exporters prior to entering export markets (which allows them to overcome entry barriers more easily). Furthermore, the results of the estimation provide us with relatively sound evidence in favour of the learning-by-exporting hypothesis, showing positive productivity gains in the period following international market entry in a significant number of Ukrainian manufacturing industries.

Several reasons for weak support of the learning-by-exporting effect found in some of the estimated industries have been suggested by the recent literature. As noted by Kogut and Zander (1996) and later discussed by Harris and Li (2007) firm's specific assets such as experience; knowledge-base; human capital assets and managerial practices are important determinants of its ability to overcome entry barriers to foreign markets. At the same time this allows us to conclude that these assets play an important role in the ability of the firm to absorb further benefits coming from exporting (Harris and Li, 2007). Furthermore, it should be noted that labour-intensive products still constitute a significant share of Ukrainian export structure. And exporters of labour-intensive products and raw materials rely mainly on the low-cost advantage rather than new technologies developed through the R&D investment. In terms of policy implications, this suggests that government policies aimed at increasing R&D investment and stimulating development of the technology-intensive sectors would increase the ability of domestic firms to overcome foreign market barriers as well as assimilate further benefits arising from exporting.

There are several possibilities for further research in the area. First, it would be interesting to study different subsets of exporting firms, for example foreign ownership versus domestic ownership. Also, with the availability of the better data covering longer periods of time, it would be interesting to distinguish between groups of older and younger firms. The last suggestion for further research is to study the impact of export destination on the magnitude of the learning-by-exporting effect. This question, however, will be partially explored in the next chapter.

3.8. Appendix. Ukrainian export-import structure, selected industries

Category	Export 2002	Import 2002	Export 2005	Import 2005	Export 2008	Import 2008
Food & beverages	2388933.75	1113761.33	4307004.9	2684081.89	10830635.3	6456568.1
Mineral products	2244887.94	7047279.28	4707983.04	11567831.37	7046089.7	25441471
Coke/ Chemical	1397046.43	1375005.12	2990247.4	3097918.28	5045387.7	6959125.1
Rubber/ Plastics	262735.1	736233.91	575238.83	1938136.24	997666.2	4476816.6
Leather/fur	159063.06	58560.96	211085.31	111179.36	359518.9	232455.4
Wood products	289678.9	84998.2	533924.35	199883.28	801168.1	545722.5
Wood/ Timber	278633.17	682004.26	454335.89	1004118.63	874402.5	1835249.1
Textile/ Cloth	654650.68	673007.43	914034.36	1406190.76	984587	2099247.4
Shoes	75961.07	53646.21	107759.95	279287.31	178099.1	531113
Textile/ Clothing	730611.75	726653.64	1021794.31	1685478.07	1162686.1	2630360.4
Stone/cast/ ceramic/glass goods	147298.89	202359.21	218679.66	516192.6	454820.3	1276483.6
Fabricated metals	7125620.2	810919.76	14047248.78	2468818.31	27633085.3	6390049.9
Machinery/ electrical machinery/ Equipment	1758609.21	2502043.63	2841800.99	6342271.65	6341164.6	13378597.5
Motor vehicles and transport equipment	689335.43	1021519.26	1655874.59	3219711.33	4324092.3	12091355.8
Medical/ precision equipment	182892.48	267213.09	141934.28	507425.38	242906.4	1222606.7
Other manufacturing	96626.67	135920.04	218408.4	323120.61	438909.6	1011012.8
Art works	79.01	500.63	186.93	732.27	723.4	4105.9
Other	198566.63	118697.51	244770.52	36554.18	242914	35444.9

Note: Selected years, 2002, 2005, 2008; expressed in '000 USD

3.9. Appendix. Ukraine geographical export-import structure

	Export 2002	Import 2002	Export 2005	Import 2005	Export 2008	Import 2008
CIS Countries	4377441.64	8968209.78	10739718.76	17030312.34	23819222.70	33569461.80
Europe	6515796.73	5751138.12	10892674.05	12670066.96	19736731.80	30475821.20
Asia	5067695.84	1171641.09	8403473.69	4644492.57	15263929.20	15306353.60
Africa	1055209.04	177295.12	2405679.38	426207.12	3903658.90	1559056.20
America	936849.94	856679.39	1831216.93	1265611.83	4144124.70	4190567.20
Australia and Oceania	4101.66	51485.17	13720.97	103951.32	63960.10	431680.50
Total, '000 USD	17957094.85	16976448.67	34286748.26	36141094.96	67002502.80	85534441.30

Note: Selected years, 2002, 2005, 2008

3.10. Appendix. Export statistics by industry

NACE code	Industry	All firms	Exporters	Exporters %	% of total
(A/B)	Agriculture/Forestry/Fishing	1,804	343	19.0%	0.5%
(CA)	Mining/quarrying of energy producing materials	607	74	12.2%	0.2%
(CB)	Mining/quarrying, except of energy producing materials	796	148	18.6%	0.2%
(DA)	Food/Beverages/Tobacco	12,725	977	7.7%	3.8%
(DB/DC)	Textile/Clothing/Leather/Fur	6,129	608	9.9%	1.8%
(DD)	Wood/Wooden products (+36)	5,383	854	15.9%	1.6%
(DE)	Paper/Printing/Publishing	8,670	198	2.3%	2.6%
(DF/DG)	Coke/Nuclear/Chemical	2467	424	17.2%	0.7%
(DH)	Rubber/Plastic	2,412	275	11.4%	0.7%
(DI)	Non-metallic minerals	4,326	365	8.4%	1.3%
(DJ)	Basic/Fabricated Metals	5,120	630	12.3%	1.5%
(DK)	Mashinery and equipment	7,545	913	12.1%	2.2%
(DL)	Electrical and optical equipment	6,794	598	8.8%	2.0%
(DM)	Transport equipment	1,583	250	15.8%	0.5%
(DN)	Manufacturing n.e.c.	4,520	380	8.4%	1.3%
(E)	Electricity, gas and water supply	3,381	44	1.3%	1.0%
(G)	Wholesale/retail trade/repair of motor vehicles	169,457	9,105	5.4%	50.3%
(H)	Hotels/Restaurants	10,388	21	0.2%	3.1%
(I)	Transport/Transport Sevices/Post	17,170	328	1.9%	5.1%
(K)	Real estate/renting/business activities	54,567	583	1.1%	16.2%
(L)	Public administration and defence	278	2	0.7%	0.1%
(O)	Community/social/personal service activities	10,935	31	0.3%	3.2%
	Totals	**337,057**	**17,151**	**5.1%**	**100%**

Note: All years

3.11. Appendix. Production function coefficients: Fixed Effects

Industry classification	Production function coefficients α_l	α_m	α_k
19 sub-sectors	0.616***	0.271***	0.111***
	(0.00472)	(0.00269)	(0.00327)
1. Agriculture/forestry/fishing	0.538***	0.379***	0.0878***
	(0.0270)	(0.0177)	(0.0193)
2. Mining/quarrying of energy producing materials	0.700***	0.521***	0.0455
	(0.0544)	(0.0375)	(0.0458)
3. Mining/quarrying, except of energy producing materials	0.640***	0.461***	-0.0612
	(0.0441)	(0.0302)	(0.0436)
4. Food/beverages/tobacco	0.361***	0.605***	0.00866
	(0.0129)	(0.00794)	(0.0101)
5. Textile/clothing/leather/fur	0.589***	0.401***	0.00639
	(0.0164)	(0.0113)	(0.0141)
6. Wood/wood products (+36)	0.431***	0.481***	0.0446
	(0.0383)	(0.0259)	(0.0289)
7. Coke/nuclear/chemical	0.473***	0.515***	-0.0254
	(0.0359)	(0.0193)	(0.0264)
8. Rubber/plastic	0.359***	0.534***	0.0118
	(0.0314)	(0.0238)	(0.0211)
9. Non-metallic minerals	0.445***	0.642***	-0.0227
	(0.0215)	(0.0149)	(0.0158)
10. Basic/fabricated metals	0.411***	0.511***	-0.00968
	(0.0205)	(0.0130)	(0.0151)
11. Machinery and equipment	0.548***	0.438***	0.000404
	(0.0171)	(0.0100)	(0.0137)
12. Electrical and optical equipment	0.610***	-0.0145	0.384***
	(0.0234)	(0.0185)	(0.0128)
13. Transport equipment	0.417***	0.492***	0.0284
	(0.0348)	(0.0203)	(0.0293)
14. Manufacturing n.e.c.	0.666***	0.384***	-0.0132
	(0.0322)	(0.0189)	(0.0213)
15. Wholesale trade	0.623***	0.203***	0.125***
	(0.0292)	(0.0165)	(0.0204)
16. Retail trade	0.676***	0.171***	0.0675***
	(0.0127)	(0.00618)	(0.00834)
17. Repair of motor vehicles	0.791***	0.137***	0.0893***
	(0.00973)	(0.00520)	(0.00662)
18. Transport/transport services/post	0.571***	0.336***	0.0553***
	(0.0123)	(0.00745)	(0.00873)
19. Real estate/renting/business activities	0.619***	0.232***	0.0491***
	(0.0101)	(0.00574)	(0.00633)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.12. Appendix. Production function coefficients: Olley-Pakes technique

Industry classification	Production function coefficients α_l	α_m	α_k
19 sub-sectors	0.568***	0.326***	0.0737***
	(0.00712)	(0.00420)	(0.0281)
1. Agriculture/forestry/fishing	0.572***	0.495***	-0.0925***
	(0.0347)	(0.0248)	(0.0343)
2. Mining/quarrying of energy producing materials	0.415***	0.387***	0.0631
	(0.0806)	(0.0574)	(0.151)
3. Mining/quarrying, except of energy producing materials	0.478***	0.574***	0.00934
	(0.0930)	(0.0547)	(0.0221)
4. Food/beverages/tobacco	0.220***	0.768***	0.0329
	(0.0183)	(0.0122)	(0.0218)
5. Textile/clothing/leather/fur	0.596***	0.446***	0.0143
	(0.0282)	(0.0174)	(0.0164)
6. Wood/wood products (+36)	0.422***	0.607***	0.0426
	(0.0844)	(0.0559)	(0.0415)
7. Coke/nuclear/chemical	0.410***	0.596***	0.211**
	(0.0658)	(0.0389)	(0.102)
8. Rubber/plastic	0.397***	0.478***	0.0323
	(0.0787)	(0.0553)	(0.0591)
9. Non-metallic minerals	0.359***	0.719***	0.0103
	(0.0382)	(0.0301)	(0.0367)
10. Basic fabricated metals	0.391***	0.634***	0.0146
	(0.0456)	(0.0311)	(0.0159)
11. Machinery and equipment	0.529***	0.453***	-0.0475*
	(0.0310)	(0.0211)	(0.0278)
12. Electrical and optical equipment	0.465***	0.542***	0.564*
	(0.0466)	(0.0259)	(0.329)
13. Transport equipment	0.532***	0.527***	0.00596
	(0.0559)	(0.0365)	(0.0272)
14. Manufacturing n.e.c.	0.361***	0.497***	0.107
	(0.0428)	(0.0275)	(0.0961)
15. Wholesale trade	0.621***	0.168***	0.171**
	(0.0517)	(0.0285)	(0.0820)
16. Retail trade	0.544***	0.210***	-0.0264
	(0.0241)	(0.0127)	(0.0506)
17. Repair of motor vehicles	0.648***	0.232***	0.00985
	(0.0161)	(0.0105)	(0.0145)
18. Transport/transport services/post	0.549***	0.285***	0.143
	(0.0261)	(0.0180)	(0.0972)
19. Real estate/renting/business activities	0.582***	0.285***	0.0173
	(0.0172)	(0.0117)	(0.0160)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.13. Appendix. Production function coefficients: Levinsohn-Petrin technique

Industry classification	Production function coefficients α_l	α_m	α_k
19 sub-sectors	0.564***	0.326***	0.0109**
	(.00594)	(.00347)	(0.0052)
1. Agriculture/forestry/fishing	0.468***	0.548***	0.341
	(0.0399)	(0.0584)	(0.294)
2. Mining/quarrying of energy producing materials	0.647***	0.346***	0.421
	(0.125)	(0.125)	(0.379)
3. Mining/quarrying, except of energy producing materials	0.752***	0.390***	-0.320
	(0.156)	(0.117)	(0.350)
4. Food/beverages/tobacco	0.313***	0.628***	0.140***
	(0.0240)	(0.0226)	(0.0282)
5. Textile/clothing/leather/fur	0.592***	0.501***	0.00454
	(0.0234)	(0.0209)	(0.0315)
6. Wood/wood products (+36)	0.318***	0.579***	0.211**
	(0.0638)	(0.0556)	(0.0920)
7. Coke/nuclear/chemical	0.332***	0.622***	0.0881
	(0.0434)	(0.0417)	(0.0575)
8. Rubber/plastic	0.185***	0.580***	0.231***
	(0.0296)	(0.0805)	(0.0558)
9. Non-metallic minerals	0.395***	0.662***	0.0630*
	(0.0573)	(0.0499)	(0.0325)
10. Basic/fabricated metals	0.309***	0.587***	0.0785
	(0.0305)	(0.0411)	(0.0491)
11. Machinery and equipment	0.506***	0.468***	0.114*
	(0.0315)	(0.0288)	(0.0667)
12. Electrical and optical equipment	0.381***	0.527***	0.0859
	(0.0364)	(0.0288)	(0.107)
13. Transport equipment	0.447***	0.518***	0.242***
	(0.0648)	(0.0529)	(0.0780)
14. Manufacturing n.e.c.	0.336***	0.430***	-0.173
	(0.0445)	(0.0403)	(0.178)
15. Wholesale trade	0.731***	0.175***	0.0128
	(0.0378)	(0.0261)	(0.114)
16. Retail trade	0.680***	0.152***	0.0575
	(0.0182)	(0.00888)	(0.0815)
17. Repair of motor vehicles	0.810***	0.211***	0.243***
	(0.0166)	(0.0117)	(0.0296)
18. Transport/transport services/post	0.420***	0.284***	0.294***
	(0.0276)	(0.0185)	(0.0445)
19. Real estate/renting/business activities	0.508***	0.284***	0.128***
	(0.0119)	(0.00901)	(0.0349)

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

3.14. Appendix. Production function coefficients: *IV* Fixed Effects

Industry classification	α_l	α_m	α_k	R^2	No. Obs. No of Groups
19 sub-sectors	.508*** (.0169)	.370*** (.0139)	.282*** (.0100)	0.60	164,985 65,780
1. Agriculture/forestry/fishing	.116 (.1599)	1.015*** (.2357)	.0265 (.1492)	0.88	2,380 760
2. Mining/quarrying of energy producing materials	.626 (.4615)	.661** (.3305)	.576** (.2687)	0.73	1,069 383
3. Mining/quarrying, except of energy producing materials	.375 (.490)	.839 (.596)	-.606** (.270)	0.72	1,084 335
4. Food/beverages/tobacco	.133** (.0691)	.833*** (.0513)	-.054 (.0367)	0.81	11,725 3,959
5. Textile/clothing/leather/fur	.540*** (.0912)	.352*** .0662	-.050 .0559	0.83	4,150 1,374
6. Wood/wood products (+36)	.179 (.2731)	.825*** (.1570)	.037 (.0983)	0.82	1,236 552
7. Coke/nuclear/chemical	.302*** (.1310)	.700*** (.0778)	-.140*** (.0663)	0.87	1,932 598
8. Rubber/plastic	.352*** (.1070)	.607*** (.1127)	-.081 (.0675)	0.88	1,318 450
9. Non-metallic minerals	.087 (.0917)	1.031*** (.0923)	.006 (.0437)	0.81	3,835 1,280
10. Basic fabricated metals	.303*** (.0654)	.612*** (.0602)	.007 (.0353)	0.82	3,277 1,154
11. Machinery and equipment	.196*** (.0676)	.669*** (.0502)	.021 (.0366)	0.89	6,276 2,097
12. Electrical and optical equipment	.079 (.1219)	.838*** (.1050)	-.086 (.0597)	0.83	3,322 1,037
13. Transport equipment	.233*** (.1084)	.612*** (.0814)	-.065 (.0727)	0.81	1,510 561
14. Manufacturing n.e.c.	.361*** (.1307)	.582*** (.0791)	-.040 (.0621)	0.72	2,694 1056
15. Wholesale trade	.747*** (.149)	.364*** (.148)	.429*** (.096)	0.56	4,784 1,908
16. Retail trade	.810*** (.0635)	.212*** (.0494)	.395*** (.0441)	0.40	30,638 12,958
17. Repair of motor vehicles	1.066*** (.0453)	.0908*** (.0380)	.207 (.0240)	0.74	26,316 8,890
18. Transport/transport services/post	.418*** (.0384)	.467*** (.0310)	.040** (.0212)	0.79	13,750 6,454
19. Real estate/renting/business activities	.605*** (.0293)	.278*** (.0278)	.024 (.0173)	0.75	20,867 8,680

Note: Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

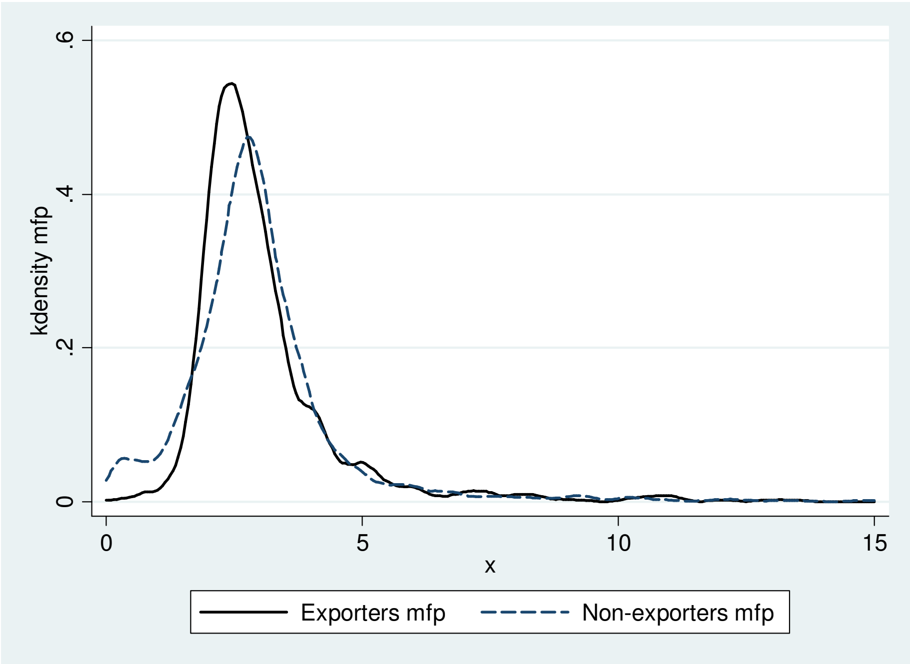
3.15. Appendix. Balancing Tests for Nearest-Neighbour Matching

	Mean				t-test	Regression based test
Industry classification / Variables	**Treated**	**Control**	**% bias**	**% bias reduction**	**t-stat(p-value)**	**F-stat(p-value)**
19 sub-sectors						
*ln*TFP	1.8418	1.7702	4.7	78.7	1.06(0.291)	0.59(0.6716)
Age	4.7624	5.0415	15.4	36.8	0.79(0.427)	0.69(0.5960)
*ln*Emp	4.5805	4.5492	2.4	94.9	0.54(0.586)	1.16(0.3271)
$\ln Emp^2$	22.799	22.488	2.5	94.2	0.54(0.591)	0.87(0.4824)
Intang	.6174	.63393	3.4	91.1	0.79(0.430)	1.45(0.2122)
Agriculture/forestry/fishing						
*ln*TFP	1.2498	1.1676	12.0	76.0	0.50(0.618)	1.38(0.2388)
Age	4.4	4.4556	5.0	70.0	0.19(0.848)	0.55(0.7019)
*ln*Emp	5.2622	5.2313	3.1	93.1	0.17(0.869)	0.68(0.6082)
$\ln Emp^2$	28.259	27.818	4.7	87.9	0.23(0.817)	0.77(0.5423)
Intang	.13333	.12444	3.2	75.3	1.09(0.279)	0.52(0.7208)
Mining/quarrying of energy producing materials						
*ln*TFP	.72312	.4984	11.0	71.0	0.26(0.796)	0.82(0.5148)
Age	4.1667	4.000	14.6	79.3	0.34(0.734)	1.67(0.1558)
*ln*Emp	6.5286	6.5234	0.3	91.0	0.19 (0.849)	0.83(0.5054)
$\ln Emp^2$	44.897	44.871	8.6	84.0	0.21 (0.836)	1.43(0.2204)
Intang	.83333	.82143	6.1	85.4	0.92 (0.368)	0.46(0.7670)

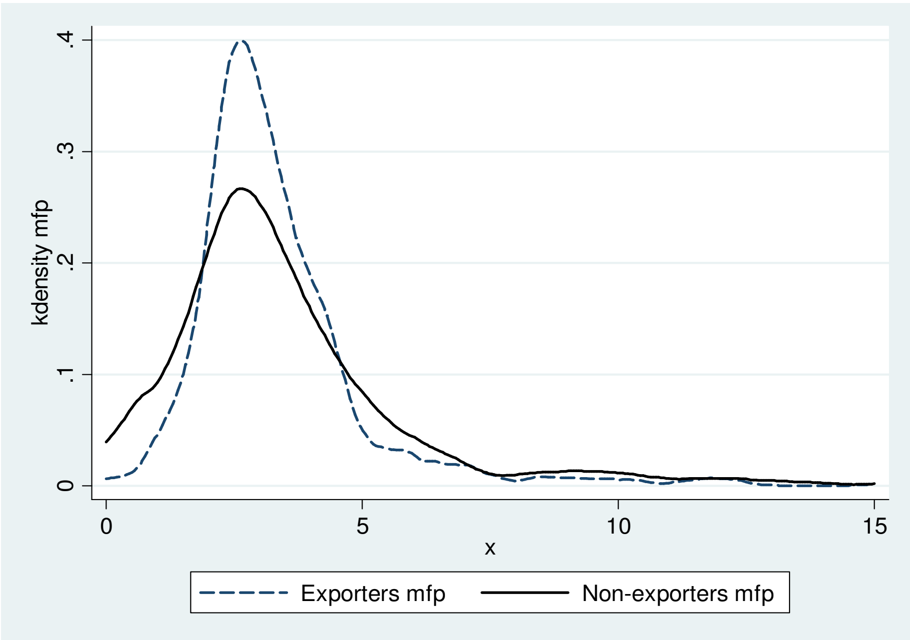
Note : Results presented for selected industries

3.16. Appendix. Productivity-level differences between exporters and non-exporters

(a) Kernel density distribution : Non-metallic minerals (DI)



(b) Kernel density distribution : Coke/nuclear/chemical (DF/DG)



Chapter 4. Ukrainian Firm-Level Export Dynamics: Structural Analysis

4.1. Introduction

In the current chapter, the focus will remain on exploring the linkages between firms' exporting activity and productivity performance. However, I will now try to widen the scope of the study to explore export dynamics at the intensive margin.

Indeed, the existence of firm-level productivity gains from international market exposure is one of the most important determinants of national trade policy. Productivity gains from engagement in international trade usually serve as a principal justification of the trade liberalization policies. Pre-entry productivity gains are associated mainly with a higher level of competition in international markets, which requires potential entrants to improve their efficiency before entry. Post-entry gains usually come in the form of increased returns to innovation, economies of scale, better managerial practices, resulting in reduced X-inefficiency.

The majority of the recent literature studying performance of the exporting firms has focused on the exporting dynamics at the extensive margin – entries into and exits from the export markets. The findings confirm mainly positive productivity gains from exporting in the short term; however, over the longer periods, some of the new entrants exit the export markets, leading to significant losses in productivity.

The analysis of exporting dynamics at the extensive margin – conducted in the previous chapter – is driven by a number of empirical studies which have confirmed the existence of significant sunk costs of exporting. For example, the empirical evidence of the sunk entry cost provided by Roberts and Tybout (1997) states that exporting in a current period increases by 36% the probability of exporting in the next period. However, at the same time, Bernard and Jensen (2004a) show that, depending on a number of years of exporting, the probabilities of exporting and non-exporting are almost the same.

Taking into account the sunk costs of exporting, potential entrants make sure that they improve their efficiency prior to the entry into the export markets by making additional investment to raise productivity level, which results in the productivity gains associated with the entry into the export markets. Also, since the majority of these investments are irreversible, exit from exporting would imply losses in the TFP.

Entry sunk costs also generate so-called “export hysteresis” – a range of inaction on the edge of entering into/exiting from exporting. Those firms that are exporting already would rather suffer temporary losses in case of a fall in demand rather than exit from the export markets instantly. This in turn implies that significant productivity decline would occur prior to the exit from exporting. On the other hand, current exporters will be the first to take advantage of any improvements in foreign demand or market conditions.

These predictions imply that entries and exits from the export markets may not play a major role in the export response that occurs in response to changes in the international economic environment, and the relationship between productivity performance and export dynamics at the intensive level deserves much closer attention.

In the current paper, I will continue working with the dataset of Ukrainian firms used in Chapter 3 to study the exporting dynamics and TFP growth at micro level. However, the focus will now be on analysis of the export dynamics at the intensive margin.

In my analysis, I follow Voicu (2008) and use an eleven-state variable to represent firm export status. The variable includes information on the firm’s export status and relative position (for exporting firms) in the industry-specific distribution of exports (the matrix would contain 10 deciles with each firm falling in a specific decile, depending on its position in the industry export distribution).

In the scope of the current analysis, I focus only on the most export-intensive manufacturing industries. I introduce the industry-specific matrix of yearly transitions across eleven states to explore Ukrainian export dynamics at the extensive (entries/exits from exporting) and intensive margins (export intensity). This approach makes it possible to explore the level of exporting activity at which firms enter into and exit from the international markets.

Previous empirical findings imply that exporting activity has a ladder structure. New entrants usually start exporting activity with small scale operations, and the majority of the firms which exit international markets appear to be small exporters. This evidence is not surprising, since the uncertainty in the international market conditions makes new exporters behave cautiously when engaging in activity in an unknown environment. Eventually those who have managed to adjust to the international market conditions increase their export volumes to the optimal levels, and the rest cease their activity.

There is also a great deal of dynamics among continuous exporters; however, most of the movements across export distribution take place between two adjacent deciles. Firms' movements across the export distribution constitute a much greater share of the industry aggregate changes in aggregate variables such as output, exports, employment and productivity, than entries and exits from the export markets. Firm-level improvements in TFP are also correlated with the type of the firm exporting dynamics. An increase in export volumes associated with improvement of a firm's relative position in the industry-specific distribution of exports is likely to result in gains in the firm's average TFP, while moving down the export distribution following a decrease in export intensity would imply losses in the average TFP.

The analysis of the chapter starts with the study of the structure of Ukrainian exporting activity, and defines the shape of Ukrainian export distribution during 2000-2005.

The second part of the chapter estimates the impact of firms' movements across the export distribution, and firms' entries into and exits from the export markets on the industry-level changes in all relevant aggregate variables – exports, employment, output and productivity.

The last section of the chapter concentrates on continuous exporters to study the impact of the type of firms' exporting dynamics (increase/decrease in export intensity) on the firm-level changes in the TFP. To study this relationship in more detail, the study distinguishes between different types of export markets, e. g. countries of the European Union and CIS; and different types of export products, distinguishing between capital- versus labour-intensive products and raw materials. This methodology also allows testing of the hypothesis that an increase in exports to the more technologically advanced markets leads to considerable gains in productivity for the exporting firms, especially when capital-intensive products are exported.

The rest of the paper is organised as follows: section 4.2 summarises the main relevant literature; section 4.3 provides a summary of descriptive statistics; sections 4.4 and 4.5 present the methodology of the empirical analysis and discuss the results. The conclusions follow in section 4.6.

4.2. Literature Review

Motivation for the current chapter is driven by three sets of literature which, to some extent, overlap with the literature discussed in the previous chapter.

Theoretical motivation stems from two related strands. The first strand includes models of exporting dynamics with heterogeneous firms and sunk costs of exporting. Major theoretical findings in this area were introduced by Roberts and Tybout (1997), Melitz (2003), Bernard, Eaton *et al.* (2003), Helpman *et al.* (2004) and contained new approaches to the analysis of firm heterogeneity and participation in international markets. One of the main findings of these models suggests that significant entry sunk costs of exporting create a range of inaction, so-called export hysteresis, at the decisional margin among the firms considering entering export markets. Different kinds of uncertainties (such as imperfect information on foreign markets, exchange rate valuations, etc.) about market conditions widen the range of inaction. In the light of the sunk costs of exporting, the firms would be inclined to keep their current export status over the range of changing economic values. Incumbents would be reluctant to exit international markets having paid sunk-costs, and potential exporters would be hesitant to enter in the light of the significant investments required to start exporting activity. This might help explain the variability of the effect of exchange rate fluctuations in different countries with the different amounts of exporting and non-exporting firms in each country. Because of the inaction range, most of the responses to changes in international economic environment are concentrated on current exporters; countries with a higher share of exporting firms would experience a larger impact of any change in the international economic environment than those targeted at domestic production. Roberts and Tybout (1997) provided one of the first empirical estimations in support of the theory of sunk costs. Using the data on 650 Colombian firms for the period 1981-1989, they relate the past to the current exporting status and show that sunk costs matter for the export participation decision; moreover, the increase in sunk costs widens the range of inaction. Their idea has been further exploited by other researchers with some alterations in the techniques and models estimated (Bernard and Wagner, 1997; Bernard and Jensen, 1999).

The second strand of literature includes models of firms' dynamic employment and investment decisions under uncertainty with significant adjustment costs of labour and capital (Hammermesh and Pfann, 1996; Dixit, 1989, 1992, 1997; Bentolila and Bertola, 1990). The results of the dynamic labour demand and investment theory imply that fixed and linear adjustment costs also generate the region of inaction in the adjustment of the use of inputs. If the value of the adjustment exceeds costs, the firm will immediately (in the case of fixed costs) or gradually (in the case of convex costs) converge to the optimal input levels, or to levels determined by the inaction region.

4.2.1. Macro- and Micro- perspective

The analysis of the relationship between firm productivity and its international activity has received much attention in the recent empirical and theoretical literature. Theoretical base of the relationship includes *neo-endoewmen* and *neo-technology* models on the macroecoomic level and theories of *technological capacity* – on the micro-level. *Neo-endowment* models consider specialization as a result of difference in such factor endowments as labour and human capital, materials and knowledge. (Roper and Love, 2002; Walekin, 1998). On the other hand, *neo-technology* models conclude that industries characterised by higher innovation levels will become net exporters (Greenhalgh, 1990, 1994). These models evolved as an extension of the standard technology-based models such as product life cycle theory and (Vernon, 1966; Dollar, 1986 and Krugman, 1979) and technology-gap theory of trade (Posner, 1961; Krugman, 1985)

In studying the links between export participation and productivity/innovativeness the issues of causality are of major importance. Causality can run either from productivity to exporting; or from exporting to productivity; and finally - in both directions (Harris and Li, 2005). There is also a range of factors that might have further effect on the exporting- productivity links (such as industry, firm, size, exchange rate and others). In a pioneering paper by Krugman (1979) nation's international trade activities was positively related to the trade-associated international technology transfer, with a further argument that the direction of causality runs from innovation to trade and not the other way around. In a classic scenario of trade between developed and developing countries innovation brings an improvement in terms of trade in developed countries, while in developing countries trade-associated technology transfer increases quality and technology level of the goods produced. One of the main policy implications of the model suggests that developed countries continuously invested in R&D activities in order to keep the level of their income and growth, because continuous transfer of production from developed to developing countries may lead to industrial decline in the former.

Krugman continued his study of trade-innovation linkages in his 1985 model of technology gap. In this model, the best-practice technology improves at constant but different rates across sectors. Less-advanced countries face longer time lags in acquiring best-practice techniques. They are thus farther behind the technological frontier (have larger technology gaps) and have a comparative disadvantage in sectors where productivity grows more rapidly. The view that international trade facilitates the transfer of technology is incorporated in the model by allowing a country's technology lag in a sector to be inversely related to the openness of the sector. The aggregate rate of productivity growth in the long run is a weighted average of sectoral growth rates with weights given by production shares. In this setup increased openness of a sector does not have a permanent effect on the productivity growth rate; however, it can raise the growth rate in transition to the long run by shortening the technology lag for the sector.
Majority of the earlier studies on the micro-level conclude that innovating firms have strong incentives to internationalise in order to widen their target markets, which in turn allows acquiring higher returns on their investment (Teece, 1986). Competitive advantage provided by innovation stimulates firms to seek international expansion (as domestic market is rather limited) and improves their performance after going global. On the other hand, increased competition in international markets, as well as higher product standards and easier access to new ideas and technologies, stimulate further innovation.

4.2.2. Resource-based theory of the firm

Another approach to study export-productivity linkages is based on the resource-based theory of the firm. The theory was initially developed by Penrose (1993) and further extended by Wernerfelt (1984); Barney (1991, 2001) and Peteraf (1993)[47]. Recently the theory was applied by Dhanaraj and Beemish (2003) and Rodriguez and Rodriguez (2005) to study export-productivity relationship. The approach explains exporting-productivity relationship via the increase in technological capacity of the exporting firm. The approach suggests that competitive advantage that provides a firm with an opportunity for internationalization depends on the firm's intangible resources that include a wide range of firm-specific assets, such as technological capital,

[47] Please refer to Harris (2005); Harris and Li (2005, 2006) for an extensive review of the resource-based approach.

organizational capital, human capital, reputation and others (Grant, 1991). As pointed out by Barney (1991) these resources are unique, scarce, valuable and unsustainable. Technological capital is of major importance, as it allows firms to develop and maintain their innovative capacity, which in turn generates and sustains their competitive advantage – a prerequisite for a successful entrance and further operation in the global markets. As discussed in Rodrigues and Rodrigues (2005) firm's technological resources transform in a competitive advantage as they help a firm develop new, more effective production processes (process innovation) as well as create a wider range of higher quality goods (product differentiation). The former provides a firm with a cost advantage and the latter allows it to better respond to consumer needs and increase the quality of its products. Thus, firms that possess better technological capacity will have a competitive advantage in both domestic and international markets. Moreover, higher level of technological resources would allow them to quicker absorb and make use of new knowledge and techniques available in the international markets, thus further improving their performance.

At the macroeconomic level vast majority of studies have confirmed the existence of a positive relationship between country's innovative activity and its exporting performance. The studies include Fagerberg, 1988; Greenhalgh, 1990; Verspagen and Wakelin, 1997; Narula and Wakelin, 1998; Leon- Ledesma, 2005; Di Pietro and Anoruo, 2006 and others.

Exporting-productivity linkages have been also extensively explored in a number of empirical studies; and most of the studies confirmed that productivity is a main prerequisite for a successful entry and post-entry performance in the export markets. These studies include a wide range of specific country studies as well as those comparing data from different countries. For example, Wakelin (1998) explores the role of innovation as a determinant of bilateral OECD trade across countries and sectors. The author finds a positive relationship between the relative innovation and trade performance on the aggregate level as well as for a number of manufacturing sectors. Moreover, the difference in innovation appears to have more impact on trade performance in sectors classified as net producers of innovation. A paper by Hirsh and Bijaoui (1985) studies the impact of innovation/R&D activities on export performance of Israel manufacturing industries. The authors develop and empirically test the model that suggests that R&D activity grants additional market power to innovating firms, making their products internationally competitive regardless of factor intensities. Thus, innovation translates into competitive advantage making innovating firms more export oriented. The results of the model are further confirmed by empirical findings that also suggest that lagged R&D expenditure was a significant determinant of variation in firms' export behaviour. Later, in his empirical analysis of the relationship between innovation, product variety and product quality and trade performance of the UK manufacturing industries Anderton (1999) confirmed that R&D and patenting activity had significant impact on trade volume and prices and thus could be considered as proxies of the quality and variety of goods produced. Other studies based on the UK data include Bishop and Wiseman (1999), Bleaney and Wakelin (2002), Goulay and Seaton (2004), and Hanley (2004).

Lefebvre and Lefebvre (2001) analysed longitudinal data on 3 032 manufacturing Canadian SMEs and found that innovative capabilities are strong determinants of export performance and behaviour. However, their importance depends on the knowledge intensity of the sector in which the firm operates. Other studies for Canada include: Bagchi-Sen (2001), and Baldwin and Gu (2004).

Cassiman and Martinez-Ros (2003, 2004) analyze the effect of innovation on the decision of firms to export using a panel of Spanish manufacturing firms for the period 1990-1999. The authors find that product innovation (product differentiation) rather than process innovation affects firm productivity, which in turn induces firms to self-select into the export markets. Other studies of this kind include Alvarez (2001) - for Chilean manufacturing firms; Guan and Ma (2003) - for China; Ozcelik and Taymaz (2004) - for Turkish Manufacturing firms and Ito and Pucik (1993) – for Japanese manufacturing firms. Also, Roper and Love (2002) implemented a comparative study for UK and German manufacturing firms, followed by Dhanaraj and Beamish (2003) - for U.S. and Canadian firms.

On the other hand, Sterlacchini (1999) in his attempt to analyse different characteristics that can potentially influence firm's export behaviour on the basis of Italian micro-level manufacturing data finds no significant impact of R&D intensity on the export orientation of small enterprises; and a positive impact – for medium and large enterprises. Other studies that found no positive association between R&D activity/innovativeness and exporting include Willmore (1999) and Lefebvre *et. al.* (1998). However, these contradicting results may be related to a number of estimation issues, discussed in Chapter 3.

4.2.3. Causality issues

Provided that most of the modern economic literature confirms the presence of correlation between exporting and innovation/productivity at the micro-level, we now turn to explore further the issues of causality between the two. As it's been mentioned above, the causality between exporting and innovativeness can run in both directions. An early strand of literature suggests that causality runs from productivity to exporting (*innovation-led exports*), which goes in line with theoretical models of *product life cycle* theory and latter *neo-endowment* and *neo-technology* models discussed before. The idea of this casual link suggests that, as discussed, innovation converts into competitive advantage that allows firms to enter foreign markets and further boosts their export performance. A number of studies provide empirical evidence on the impact of innovation variable on export behaviour of the firm. Such studies include Bleaney and Wakelin (2002); Barrios *et. al.* (2003); as well as discussed earlier studies by Cassiman and Martinez-Ros (2003) and Starlacchini (2001).

Another set of literature points out at the direction of causality running from exporting to productivity/innovativeness. The idea of this casual link goes in line with theoretical models of endogenous growth (Romer, 1990; Grossman and Helpman, 1991; Aghion and Howitt, 1998) as well as with the resource-based theory of the firm discussed earlier[48]. The impact of exporting activity on the firm's innovation capabilities is measured through the impact on its productivity growth and is known as *learning-by-exporting effect*. Majority of the literature in this area is empirically-driven and analyses learning-by-exporting hypothesis by estimating the impact of exporting activity on the variable that can be considered proxies for the firm's innovativeness/learning capacity (such variables as TFP and labour productivity)[49].

Finally, a two-way linkage between firm's exporting and innovativeness (proxied by various productivity measures), when causality runs in both directions, has been less developed in the literature due to data paucity and lack of plausible econometric techniques. Overall, the evidence of bilateral exporting-productivity relationship is mostly found in studies on developing countries. This feature may be related to the fact that developing countries form a very heterogeneous group and experience more significant effects from trade, compared to their developed counterparts. Moreover, studies by Ben David and Loewy (1998) and Guillen (2001) also confirm that developing

[48] Please refer to Harris and Li (2005, 2006) for a comprehensive discussion of the resource based theory of the firm.

[49] See Chapter 3, section 3.2 for a more-detailed review of learning-by-exporting empirical literature.

countries do gain more from trade with more advanced countries in terms of technological and economic convergence. For example, Alvarez (2001) using the micro-level data for Chilean manufacturing industries considers three main channels of technology transfer: exports, foreign direct investment and purchase of foreign licenses. The author finds that exporting activity has the most significant impact on technological innovation, while two other channels are less important. Moreover, his findings confirm that causality also runs the other way; i. e. innovation increases the probability of exporting, however, only in case a firm possesses a certain level of innovation intensity (which is consistent with the resource-based theory of the firm). The evidence in favour of reciprocal relationship between R&D/innovation and exporting has been further confirmed by Zhao and LI (1997) and Guan and Ma (2003) for two different samples of Chinese manufacturing firms.

4.2.4. Extensive versus intensive margin

Finally, when estimating exporting-productivity relationship it is important to distinguish between extensive and intensive margins of trade and their relative importance for trade growth.

First generation of international economics models studying growth in international trade volumes in cases of trade liberalization relied heavily on existing trade patterns. Real business cycle models that use Armington (1969) aggregator (or trade in a composite good), as well as factor proportion models, suggest that growth in trade volumes is mainly driven by intensive margin, i. e. a double rise in a nation's resources results in a double increase in export volume of traded goods, but not in an increase in the variety of traded goods. On the other hand, models of imperfect competition (i. e. Krugman, 1981) suggest that double rise in a country's resources would lead to a double increase in the range of traded goods. Vertical differentiation models (Flam and Helpman, 1987; Grossman and Helpman, 1991) rely on the quality margin, namely, richer countries tend to export higher-quality goods.

Recently, the relative importance of extensive and intensive margins has been addressed in a number of empirical studies. It should be mentioned that different studies apply different definitions of extensive and intensive margins of trade. For instance, Felbermayr and Kohler (2005) define intensive margin as an increase in trade volume within the framework of the established trade relationships and extensive market – as a start/cease of a new/existing trade relationship. Also, Voicu (2009) in his study of exporting-productivity linkages on the basis of Hungarian manufacturing firms defines

extensive margin – as entry/exist into/from foreign markets; and intensive margin – as an increase/decline in the export volumes of an incumbent exporter. The same definition was applied by Melitz (2003). On the other hand, Helpman, Melitz and Rubinstein (2004) define intensive margin as trade between existing trade partners (countries) and extensive margin – trade between new trade partners (countries). Hummels and Klenow (2005) define an intensive margin as an increase in the volume of exports of existing goods; and extensive margin – as an increase in the range of exported goods. In their paper the authors use data on shipments by 126 exporting countries to 59 importing countries in 5,000 product categories to find out which margin matters more in the structure of nation's exports. Their findings suggest that extensive margin accounts for about 60% of the greater exports and for about 30% of greater imports of larger economies. With respect to product categories, the authors found that richer countries export more of each product with a modest price increase (which implied higher product quality). Kehoe and Ruhl (2002) study the bilateral trade patterns of countries involved in substantial trade liberalization. Making use of the data on the value trade flows by commodity they find that a set of goods that accounted for only 10% of the total trade volume before trade liberalization may account for up to 40% of the trade volume after trade liberalization. This aspect is not properly reflected in the first generation models of international trade that assume fixed international trade patterns.
Second generation of international trade models (Bernard and Jensen, 1995, 1999, 2001, 2004a; Clerides et.al., 1998; Eaton, Kortum and Kramarz, 2004; Melitz, 2003; Chaney, 2005) have taken into account firms' heterogeneity and suggested a positive correlation between export activity and firm productivity and size.

4.2.5. Other empirical studies

The availability of the new more detailed micro-level datasets has fuelled the empirical analysis of the intra-industry firm heterogeneity and domestic micro-level effects of trade liberalization policies in a large number of countries. A whole set of studies investigated the consequences of trade liberalisation experiments on the domestic market (i.e. NAFTA effect, etc.). The majority of the empirical studies on the impact of trade liberalisation on the structure of domestic industries concentrate on the three main trade channels: import discipline effect, scale effect and turnover hypothesis. Import discipline effect leads to an increase in manufacturing productivity, as trade liberalisation exposes domestic producers to greater competitive pressure. It affects productivity in three ways: it reduces X-inefficiency, forces firms to increase their output and improve their scale efficiency, increases firms' incentive to innovate. Scale effect is believed to have a positive productivity impact owing to the access to international markets, which should theoretically lead to an increase in output leading to the economies of scale. Turnover hypothesis states that increased competitive pressure would make the least productive firms exit the markets, leading to aggregate productivity gains.

The effect of trade liberalisation has been investigated by many scholars. Papers by Pavcnik (2002), Tybout and Westbrook (1995), Muendler (2002) studied the effect of trade liberalisation policies on the structure of domestic industries in Chile (1979-1986), Mexico (1986-1990) and Brazil (1986-1998). All studies confirm the presence of the strong positive productivity effect of trade liberalisation.

Tybout and Westbrook (1995) estimate the firm-level productivity impact of the trade liberalization policies on Mexican manufacturing industries during the period 1984-1990. In 1985, Mexico implemented a massive trade liberalization programme, which involved elimination of import licensing requirements and a significant reduction in tariff rates. The authors decompose industry-wide productivity changes into three components: reallocation of output shares between firms with different average costs of production; firm-level economies of scale effect, and a residual term that shows an increase in the firm's multifactor productivity. The results of the paper imply that efficiency gains as a result of the economies of scale were minor, compared with the firm-level multifactor productivity gains that appeared to be the dominant source of aggregate efficiency gains during the sample period. The increase in productivity was shown for most of the manufacturing sectors, with the largest gains registered in the import-competing sectors. Most of the sample sectors also show a significant reduction in the average cost. However, for the export-oriented sectors, the fall in the average cost of production was mostly the result of favourable changes in relative prices. This study was one of the first in the area, and was followed by a number of similar studies for different countries.

For example, Pavcnik (2002) empirically estimated productivity gains for a panel of Chilean manufacturing firms. The period of study covered the years 1974-1986, and provided a perfect example of an investigation into the dynamics of the firm's responses to trade liberalization. During this time, the country reduced all tariff rates to a uniform *ad valorem* tariff of 10% across all industries; the only increase in tariff was made in

1983-1984 after the 1982-1983 recession. The results show that, on average, trade liberalisation raised firms' productivity, with the increase being significantly higher in the import-competing and export-oriented (traded goods sectors). Least productive firms were forced to exit the market, which increased overall industry productivity. Overall, the results of the paper confirm the major role of the firm-level multifactor productivity in the aggregate productivity gains for the Mexican manufacturing industry.

The paper by Lopez-Cordova (2002) studied the impact of trade and investment liberalization following the adoption of the North American Free Trade Agreement (NAFTA) on Mexican manufacturing during 1993-1999. In particular, the paper studied the evolution of the multifactor productivity at firm level. The author explored the links between the evolution of the firm-level total factor productivity and imported intermediate inputs, foreign capital participation, export activity, import penetration and tariff rates in Mexico and the United States. The results of the paper suggest that foreign capital participation and increased import penetration had a positive effect on the total factor productivity, while there is no clear effect of the increased use of the imported inputs or exporting operations.

Overall, the empirical studies of the effect of trade liberalisation policies on the domestic industry structure confirm positive aggregate and firm-level productivity gains. Moreover, the gains are higher for export-oriented traded goods sectors. However, since the range of inaction prevents domestic firms from entering export markets, the majority of responses to trade liberalization are still concentrated on current exporters. Recent empirical findings support this view. For example, Bernard and Jensen (2004b), in their study of export response of the US manufacturing plans to dollar depreciation in the 1980s, argue that fluctuations in the exchange rate will mostly affect current exporters and lead to changes in the intensive rather than extensive margin. They report that 87% of export expansion was the result of the increase of export intensity by current exporters and only 13% from the entry of new firms. Similar results have been reported by Bugamelli and Infante (2002), who used the data on Italian manufacturing firms for the period of 1982-1999 to study the effect of sunk costs on export market participation. The results of the paper show that the probability of exporting increases by 70% if the firm has been exporting in the previous period, which means that sunk costs matter for decisions on export participation. To check the robustness of the results, they also included a number of firm-specific characteristics and macroeconomic regressors in the analysis. They also show that the impact of sunk costs on export participation is negatively related to the firm size. Their results suggest that sunk costs create a barrier to entry into export markets, especially for small and medium-sized firms.

Baldwin and Gu (2003), in their study of the effect of NAFTA on Canadian firms, reported an increase in both the number of exporters and export intensity. They also found a substantial policy effect on the export entry decision (4.5 percentage points reduction in the US-Canada tariffs increased the probability of exporting by 63%). Blalock and Gertler (2004) studied the effects of trade liberalisation in Indonesia during the period 1990-1996, and found that the number of exporting firms had doubled during the sample period.

There is currently little evidence on which particular aspects of trade policies are more important for export volumes, and which parts will have more significant effect on the domestic industry. For example, tariff reduction might lead to improvements in firms' productivity owing to the reduced costs of intermediate inputs or increased market competition (import discipline effect), which may facilitate entry by non-exporters into export markets, and at the same time make it easier for current exporters to increase their export sales to existing or new markets.

In the current chapter, we will take into account the experience of the previous researchers, and analyse the impact of trade liberalization policies on the structure of the four main Ukrainian manufacturing industries and then continue with the analysis of the impact of the intensive margin of export[50] on the firm-level productivity.

[50] Intensive margin – increase in the export volumes of a firm; extensive market – entry/exit into/from the foreign market.

4.3. Stylized Facts about Firm-Level Exports

As has been mentioned before, the dataset under study covers 22 Ukrainian manufacturing and service sectors the period of 2000-2005. For convenience, I have chosen four most export-intensive sectors out of the 22 sectors initially included in the sample. Table 4.1 below reports the summary statistics for several key variables in the subsample of four sectors. The first column reports the total number of firms and observations, and provides the means of several variables. The second and third columns break down these numbers by exporting and non-exporting firms.

Table 4.1. Descriptive statistics

	Total	Non-exporters	Exporters
Observations	49315	40999	8316
Firms	17149	14099	3050
Employment	364	128	455
Sales (thousand USD)	12182.12	5568.797	28088.42

Source: Database used in the analysis.

The exporting behaviour of the firms included in the sample reveals substantial heterogeneity in the firms' export patterns. 82% percent of firms do not export at all. Exporters tend to be larger and more productive than non-exporters. As seen from Table 4.1, exporters employ 3.5 times as many workers and sell 5 times as much. They are also more likely to import intermediate inputs. This fact is consistent with the findings of Bernard *et al.* (2003), who show that firms engaged in international trade on average outperform their domestic counterparts in a number of dimensions. Also, this fact is in line with the hypothesis of the sunk entry costs of exporting. It is logical that larger firms would find it easier to make the irreversible investments required to enter foreign markets. An interesting observation is that, over the observed time period, exports have mostly increased at the extensive margin; i.e. more firms have entered the export markets. Appendix 4.7 shows the fraction of exporting firms in the total number of observations by year and industry, as well as the share of exports in the total sales. As can be seen from the table, despite the fact that the number of exporters has increased during the observed time period, the share of exporters in the total number of observations as well as export share in total sales exhibits no clear time trend.

4.4. Empirical Analysis

The goal of the empirical analysis in the current chapter is to study the firm-level export dynamics of the four Ukrainian manufacturing industries during the period of 2000-2005 and analyze the impact of changes in firm-level export intensity on the firm-level TFP growth. A has been mentioned earlier, I have chosen four most export-intensive sectors out of the twenty two sectors initially included in the sample. The chosen sectors include: coke-chemical-nuclear, non-metallic minerals, machinery and equipment, and the transport equipment sector.

The coke-chemical-nuclear sector includes export products such as mineral fuel, oil and processed products (27); non-organic chemical products; organic and non-organic compounds of precious and rare-earth metals, isotopes and radioactive elements (28); organic chemical compounds (29); fertilizers (31); other chemical products (38).

The non-metallic minerals sector includes mostly export goods such as salt, sulphur, grounds and stones, plaster materials, lime and cement (25); goods made of stone, cement, gypsum, asbestos, mica and similar materials (68); ceramic products (69); glass and glass products (70).

The majority of the export goods in the machinery and equipment sector are wood and wood products, charcoal (44); tools and cutlery (82); nuclear reactors, boilers, supporting mechanic equipment and parts (84); electric equipments and parts, sound and TV recording and audio equipment and parts (85); optic, photographic, cinematographic equipment, meters, and check meters; precision, medical and surgical devices and parts (90).

The transport equipment sector includes plastic and plastic goods (39); rubber and rubber goods (40); transport vehicles except for rail transport (87); copper and copper products (74); aluminium and aluminium products (76); other non-mentioned precious metal products (83).

It has to be mentioned that the period under study encompasses the devaluation of the Ukrainian national currency Hryvna and an overall economic downturn of 2001-2002, followed by a relatively rapid recovery, which prevailed until the recent economic turmoil of 2008-2009. Different aspects of Ukraine relationships with its main trade partners, such as CIS countries, countries of the EU, US and China, should also be taken into account. Being a member of the CIS, Ukraine used to build its trade relations with the CIS countries on the basis of the bilateral Free Trade Agreements that have been concluded between all the CIS members. Trade relations between EU and Ukraine during the period of study were based mostly on the Partnership and Cooperation Agreement (PCA) that was put in place in 1998. Two additional agreements were developed to regulate Ukraine exports of some steel and textile products. The last agreement on steel products was in force from 1998 until the end of 2007, and has assigned Ukraine a quota of 1,320,000 tonnes of steel products per annum. The agreement has been renewed on a yearly basis, with quantities of each product increasing by 2.5% each year, and was terminated on the 21st of May 2009 - the date of Ukraine's accession to the WTO - with all the quotas having been lifted since then. The bilateral trade agreement between the US and Ukraine, which is quite similar to the EU-Ukraine PCA, also implies quantitative restrictions on the export of steel, textile and agricultural products from Ukraine.

Overall, the index of Ukraine's Trade Freedom provided by Heritage Foundation and Wall Street Journal has increased from 70 to 76.2 during the period 2000-2005, which confirms the gradual liberalization of Ukrainian trade.

In the current paper, I analyse the dynamics of exporting activity in four Ukrainian manufacturing industries at the extensive and intensive margin. Following Melitz (2003) and Hummels and Klenow (2005), I define intensive margin as a change in the export volume of continuing exporters, and extensive margin – as entries/exits into/from the export market.

In particular, the study estimates the export intensity of the new exporters immediately after entry into the export markets; export intensity of the firms exiting export markets immediately prior to exit, and the distribution of changes in the relative positions of current exporters in the industry-specific export distribution.

Further, I implement Haltiwanger (1997) productivity decomposition in order to estimate the contribution of different sub-groups of firms (i. e. entering, exiting and continuing firms) to the aggregate industry productivity growth. Finally, I explore exporting-productivity linkages concentrating on continuing exporters. In particular, I estimate the impact of changes in the export intensity on each firm's TFP. In order to provide a more detailed analysis of the issue, I distinguish between different types of export markets. The theory predicts larger productivity gains from exporting to the countries of higher levels of technological development, especially when capital-intensive products are exported. To test this hypothesis, we estimate the productivity impact of changes in export volume for continuing exporters, concentrating on different export markets, such as countries of the European Union (EU) and countries of the Commonwealth of Independent States (CIS), and different product categories, such as raw materials and labour-intensive products versus capital-intensive products.

4.5. Analysis of Export Trends

4.5.1. Industry-level dynamics

We start our analysis with a description of the dynamics of micro-level exporting activity in the four industries under study. I start the analyses by obtaining the export volumes of those firms entering export markets in the period following entry, and export volumes of those firms exiting the export market in the period preceding exit. I then analyze the contribution of different subgroups of firms (i. e. entering, exiting and continuing firms) to the changes in the industry aggregate productivity growth distinguishing between exporting and non-exporting firms.

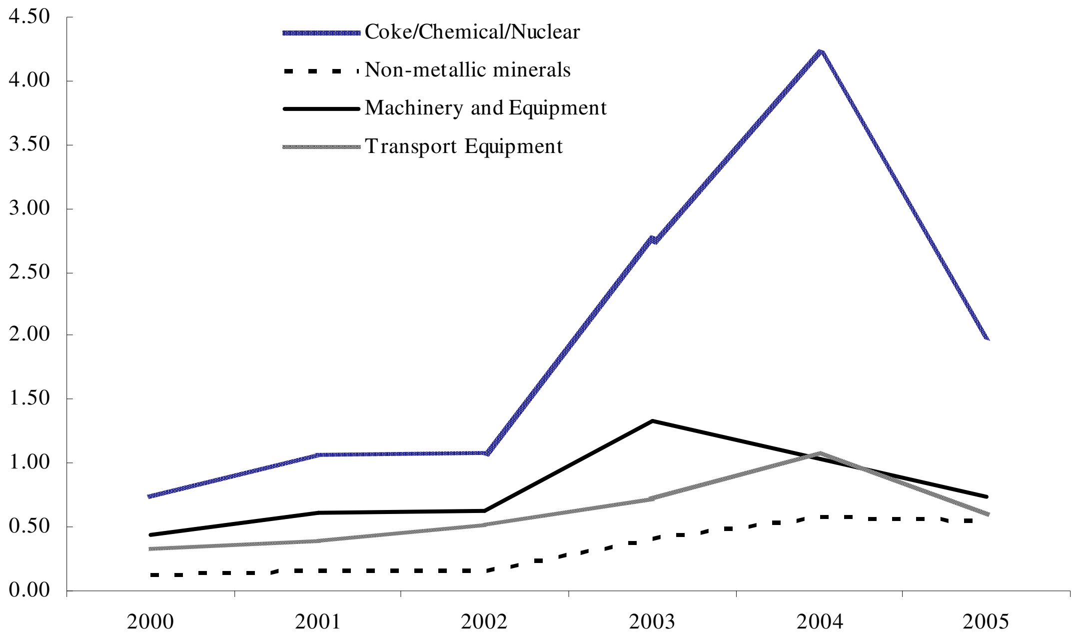
Appendix 4.7 shows the number of exporting firms, export and domestic sales by industry. In all four industries, firms have been exporting a significant part of their output during the period 2000-2005. At the beginning of the period, the coke/nuclear/chemical, transport equipment; machinery and equipment and non-metallic minerals industries show 26, 22, 17 and 10 percent of exporters out of the total number of firms (export intensity) in each industry respectively.

The coke/nuclear/chemical industry shows the strongest growth in export sales, with a total increase of 1.3 billion USD. The non-metallic minerals industry has the highest increase in the share of exports in the total sales: 323 percent. This is caused mostly by the steep decline in domestic sales in this industry towards the end of the period.

In all four industries, the number of exporters increased significantly during the period 2000-2005. The significant growth in the share of export sales in all four studied industries is followed by a relatively steep decline in 2004-2005 (Figure 4.1). The negative trend in the export share is caused by the overall significant increase in domestic sales, causing a corresponding decline in the export intensity. One of the possible explanations for this phenomenon is the high exchange rate in 2004-2005, which might have caused unfavourable conditions for exports.

The numbers still show positive dynamics of export volumes, with an overall increase of 2.2 billion USD in real terms over the period of study. Export sales in all four industries have increased by 136 percent; the number of exporting firms has increased by 21 percent, with most of the increase taking place in 2003-2005. Export intensity has exhibited a weak positive trend (4.86 percent of total sales in 2000, and 5.15 percent of total sales in 2005), which can be explained by the overall increase in domestic output volumes, as domestic sales more than doubled during the period of study (32 billion USD in 2000, 71 billion USD in 2005[51]).

Figure 4.1. Dynamics of export sales by industry, 2000-2005, billion USD



Source: Own calculations

4.5.2. Firm-level dynamics

Obviously, the industry dynamics described in the previous section are the outcome from individual firm responses to the constantly changing conditions of the economic - and particularly international - trade environment.

Appendix 4.8 shows the yearly changes in the percentage of firms in the sample that exit the market, the percentage of firms which start/stop exporting, and the percentage of exporting firms increasing/decreasing their export sales by 25 percent or more.

[51] Prices are deflated to the base year 2000

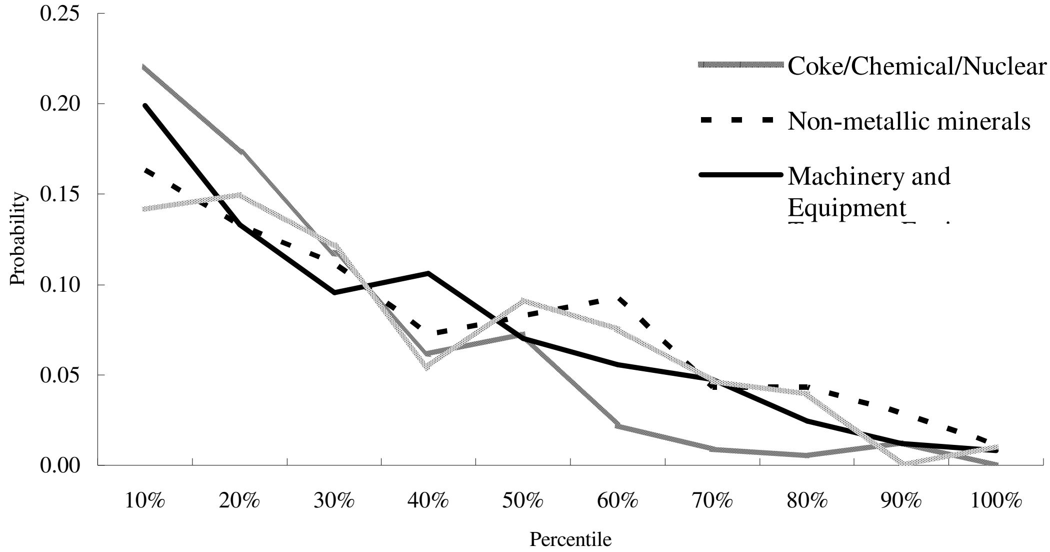
The changes in export status show a high degree of heterogeneity at the extensive and intensive margin. All four industries exhibit similar time trends, with the highest exit rates falling on 2001-2002, the years of the economic downturn. The percentage of entries and exits from the export markets slowly decreases towards the end of the period, confirming the more stable economic environment during the period 2003-2005.

The level of heterogeneity is even higher at the intensive margin. In all industries, the percentage of exporting firms that increase or decrease their export sales by more than 25 percent remains significant in all years, with rates varying between 30-45 and 50-65 percent respectively.

In the following section, I will try to provide a more detailed analysis of the changes in the firm's exporting activity. In doing so, and following Voicu (2008), I construct an eleven-state variable to characterise the firm's export status. The variable takes value 0 if the firm does not export and a value between 1 and 10 if the firm exports. The value of the variable for an exporting firm depends on its relative position in the industry-specific export distribution. To construct the variable, I break the distribution of export sales into percentiles. Hence the variable will take value 1 for all firms that fall within the lowest 10% of the industry export sales, and value 10 for all firms that fall within the highest 10% of the industry export sales. The construction of the variable confirms that exporting firms form a heterogeneous group at any point in time.

Yearly transitions across export distribution provide a good reflection of the trends that prevailed in exporting activity during the period 2000-2005 at both extensive and intensive margins. I use eleven-states variable of the export-status to construct the probability that a firm entering the export market will occupy one of the 10 deciles (percentiles) of the industry-specific export distribution in the entry year, Prob ($Export\ Decile_t \mid Entry_t$) and the probability that a firm exiting the export market will exit one of the 10 deciles of the industry-specific export distribution in the year of exit, Prob ($Export\ Decile_t \mid Exit_t$). This exercise will help identify prevailing export decision patterns.

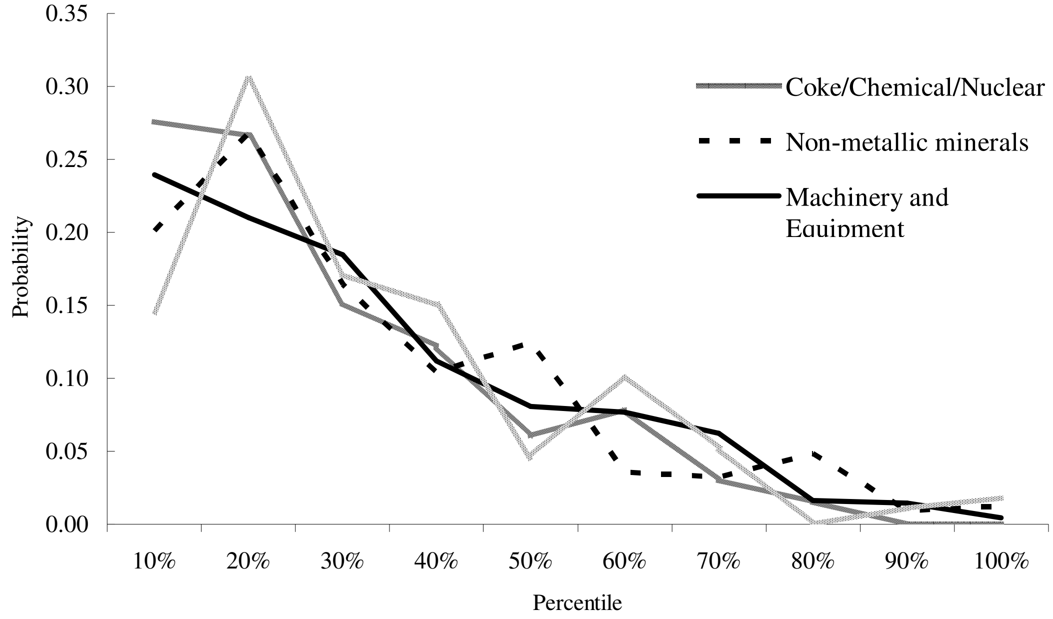
Figure 4.2. Distribution of entries into the export markets by deciles of export distribution, 2000-2005, yearly transitions



Note: Probability of entering into specific percentile of export distribution. Own calculations

Figure 4.2 compares the probability of entering the specific decile of export distribution for each of the four industries under study. It shows that the majority of firms which start exporting engage mostly in small scale operations. This pattern prevails in all four industries. Around 20% of the new entrants start their exporting operations at the bottom 10% of the industry-specific export distribution, with the probability of entering exporting markets declining steeply towards the top of the distribution. The first decile accounts for about 15-25% of all the entries into the export markets, and the first two deciles together account for about 25-40% of all entries. About 60% of all entries occur below the median of the export distribution.

Figure 4.3. Distribution of exits from the export markets by deciles of export distribution, 2000-2005, yearly transitions



Note: Probability of exiting from specific percentile of export distribution. Own calculations

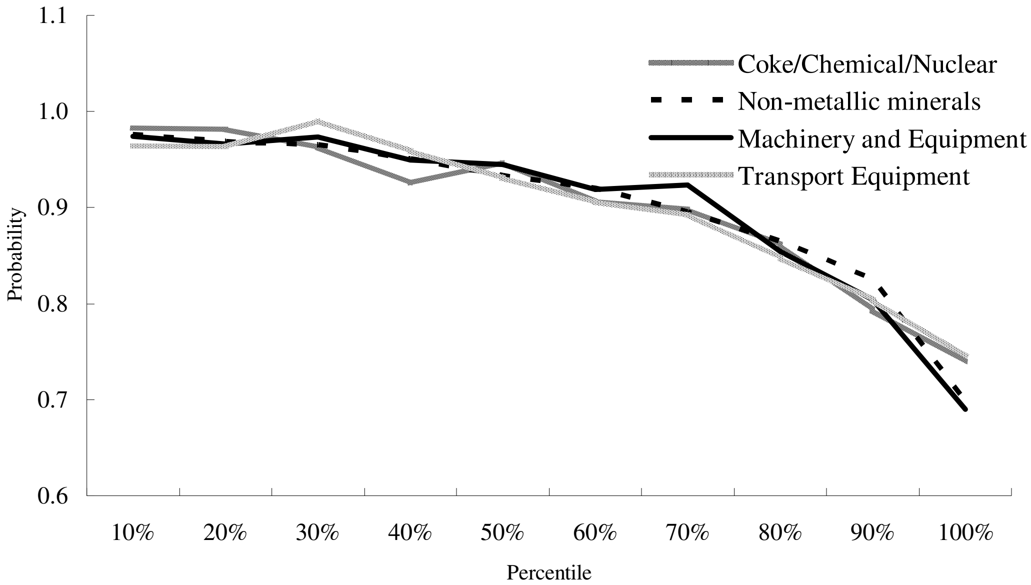
Figure 4.3 compares the probability of exiting the specific export decile across deciles of each industry export distribution, Prob ($Export\ Decile_t$ | $Exit_t$). The figure shows that the probability of exit is much higher for small exporters. In all of the industries under study, the highest probability of exit occurs at the two bottom deciles of the industry-specific exports distribution decreasing rapidly across deciles. The two bottom deciles account for about 45-60% of all exits, and about 80% of all firms that exit have export sales lower than the industry median. The same pattern prevails for all industries.

In order to analyse the dynamics of exporting activity at the intensive margin, we concentrate on continuous exporters and use the yearly transitions across deciles of the industry-specific export distribution. As reflected in Figure 4.4, the range of the probability of a firm changing its relative position in the industry-specific export distribution lies between 70 and 95 percent, with an inverted-J shape graph, which is similar to previous findings. However, current findings differ significantly from the previous empirical evidence[52], the main difference being a high probability of changing relative position in the export distribution, even for larger exporters.

[52] According to Voicu (2008) the probability of a firm to change its relative position in the industry-specific export distribution ranges between 20% and 90% for a set of Mexican manufacturing firms.

Most of the papers report the high mobility for the firms at the middle and bottom of the export distribution and low mobility for large exporters. In our case, even large exporters have a high chance of changing their relative position in the distribution of exports; while their probability of changing position is lower than that of smaller exporters it is still as high as 70%.

Figure 4.4. Distribution of changing relative position in the distribution of exports, 2000-2005, yearly transitions



Note: Probability of changing decile rank in the industry specific export distribution. Own calculations

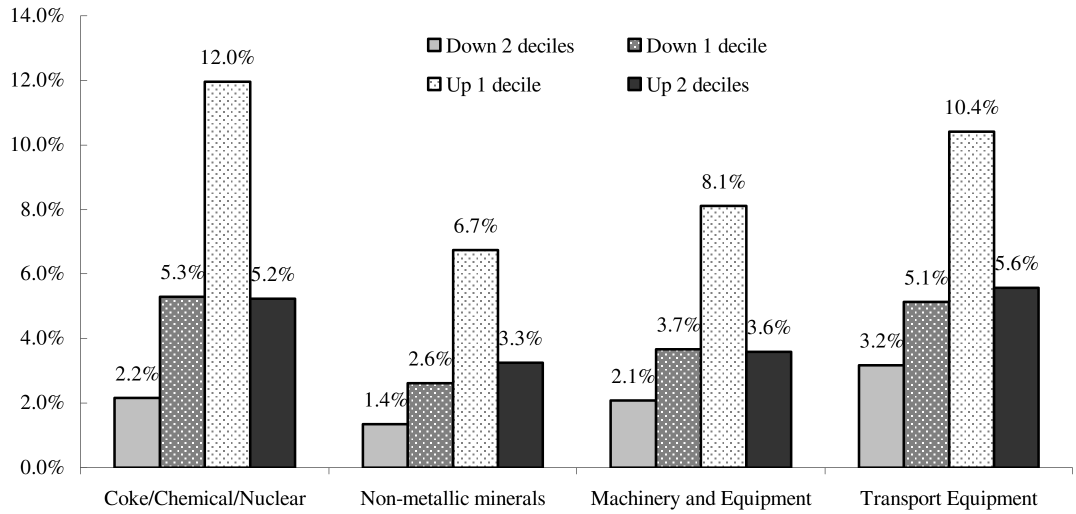
Another interesting finding of the current dataset is the range of changes in the relative position of the continuous exporters. The majority of the papers show that most of the movements across the industry-specific export distribution take place between adjacent or within two deciles. In the current case, however, movements between two adjacent deciles account for only 10-17 percent of all changes, and movements within two deciles – for 14-25 percent, with the highest percent of firms moving up by one decile (Figure 4.5).

The trends of the firm-level exporting dynamics reveal several patterns that can be summarised as follows:

- ✓ New entrants into the export markets usually operate on a small scale;
- ✓ The highest percentage of the firms that exit the export markets are small exporters;

- ✓ The low deciles of export distribution can be characterised by higher levels of mobility at both extensive and intensive margins;
- ✓ Both extensive and intensive mobility decreases towards the top of the distribution, with the firms occupying top deciles possessing a lower probability of changing their relative position or export status.

Figure 4.5. Firm mobility across industry specific export distribution, 2000-2005, yearly transitions



Source: Own calculations

4.5.3. Export - productivity links

The results of the previous sections confirm the intensive heterogeneous dynamics of continuous exporters. The results also indicate that the majority of the firms entering and exiting the export markets are small-scale exporters. This shows the importance of the export dynamics at the intensive margin for the levels of aggregate industry growth, as well as for the relationship between exporting and productivity at firm level.

This section starts with estimating the contribution of different sub-groups of firms to the industry aggregate productivity growth distinguishing between exporting and non-exporting firms and explores the export-productivity linkages of continuous exporters based on the movements of individual firms across the deciles of the industry-specific export distribution. More specifically, when analysing the impact of changes in export intensity on the firm-level TFP, I distinguish between firms that increase/decrease and do not change their export intensity, thus moving up/down or keeping their position in the distribution of industry exports. Furthermore, I break down the analysis to explore the export-productivity relationship at the intensive margin for the specific export markets and products. I concentrate primarily on the groups of economically advanced countries versus countries that are at similar stages of economic development. This strategy should allow checking the hypothesis that increasing exports to the more developed markets with the more advanced technologies leads to considerable gains in productivity for the exporting firms. It should be noted, however, that more productivity gains are expected if exported products are capital intensive goods that require a relatively advanced production process. In such cases, an exporting firm can benefit extensively from international trade via access to new innovative technologies, managerial practices etc.

4.5.3.1 Haltiwanger decomposition

I start with the analysis of the contributions of different sub-groups of firms to the aggregate industry productivity growth for each of the four industries under study. For that purpose I use the Haltiwanger (1997) and Foster et al. (2001) productivity decomposition.

Using the estimates of the firm-level TFP[53] obtained in Chapter 3 we can calculate the index of aggregate productivity in the year *t* and its growth between year *t* and *t-k*, which is defined as a geometrically weighted average of individual firm-level productivity in the industry:

$$\begin{aligned} \ln P_t &= \sum_i \theta_{it} \ln P_{it} \\ \Delta \ln P_t &= \ln P_t - \ln P_{t-k} \end{aligned} \tag{3.17}$$

In equation (3.17) θ_{it} stand for the share of gross output for the firm *i* in the period *t* for the industry (in 2000 prices), and *P* is a measure of productivity (TFP in our case).

The Haltiwanger (1997) decomposition of productivity growth distinguishes between several groups of firms: firms that operated between periods *t* and *t-k*; new firms that entered the market in period *t*; and firms that exited the market at period *t*, having contributed to the aggregate productivity growth in period *t-k*. Thus we define the aggregate productivity growth between *t* and *k* (i. e. $\Delta \ln P_t$) as:

$$\begin{aligned} \Delta \ln P_t = \sum\nolimits_{i\in C} \theta_{it-k} \Delta \ln P_{it} + \sum\nolimits_{i\in C} \Delta\theta_{it} (\ln P_{it-k} - \ln P_{t-k}) + \\ \sum\nolimits_{i\in C} \Delta\theta_{it} \Delta \ln P_{it} + \sum\nolimits_{i\in N} \theta_{it} (\ln P_{it} - \ln P_{t-k}) - \sum\nolimits_{i\in X} \theta_{it-k} (\ln P_{it-k} - \ln P_{t-k}) \end{aligned} \tag{3.18}$$

[53] Here I use the estimated of TFP obtained using FE2SLS method,

In the equation (3.18) *C* denotes continuing firms; *N* denotes entering firms *X* denotes exiting firms. The first term represents within-firm component based on the firm-level productivity changes of continuing firms open in both periods *t* and *t-k*, weighted by their initial shares in the industry output. Second term represents a between-firm component that reflects changes in the output shares of continuing firms, weighted by the deviation of firm productivity in the year *t-k* form the initial industry index in the year *t-k.* Third term is a cross (covariance) term that considers whether increases in the productivity of continuing firms correspond to the increase in their output shares. Finally, fourth and fifth term represent the contribution of entering and exiting firms, weighted by the deviation of the firm productivity (in years *t* and *t-k* respectively) from the industry average in the base year (*t-k*). Last term is expected to be negative (due to lower productivity of exiting firms), that is why the term enters equation (3.18) with a negative sign to allow for a positive impact on the aggregate productivity. I estimate equation (3.18) for each of the four studied industries. Following Harris and Li (2009) I distinguish between exporting and non-exporting firms to see how these two groups differ in their contribution to productivity growth[54].

We start with calculating output shares (θ_{it}) for different subgroups in periods *t* and *t-k* (year 2005 and 2000 respectively). The results, presented in the Table 4.2, provide output shares for exporting and non-exporting subgroups of firms in each of the industries in 2000 and 2005. As we can see, all four industries demonstrate large shares for entering and exiting firms over the period, which might be related to the fact that openings and closures are cumulative. Thus, the shares of entering and exiting plants are higher the longer is the period under study. Overall, output shares are much higher for exporting firms in all four studies industries. In three out of four industries however, output shares for continuing exporting firms decrease over the period, and the same tendency persists for non-exporting firms.

[54] According to Harris and Li (2009) the use of productivity decomposition for separate sub-groups of firms (i. e. exporters and non-exporters) "is the correct approach as it involves consistent disaggregation of the data" (p. 225). Such approach however implicitly assumes separate between-firm effects for each of the sub-groups, which is not entirely true. However, including between-group resource reallocations would significantly complicate the analysis.

Table 4.2. Output Shares. Separate Subgroups, 2000-2004.

	Continuing firms, (t-k)	Continuing firms, (t)	Entering firms, (t)	Exiting firms, (t-k)
Coke/chemical/nuclear				
Non-exporters	3.83	1.89	8.64	1.77
Exporters	61.14	42.49	46.98	33.24
All	64.97	44.38	55.62	35.01
Non-metallic minerals				
Non-exporters	26.27	19.52	12.58	8.07
Exporters	46.37	32.76	35.13	19.28
All	72.64	52.28	47.71	27.35
Machinery and equipment				
Non-exporters	23.43	09.38	27.54	18.41
Exporters	33.59	26.12	36.95	24.56
All	57.02	35.50	64.49	42.97
Transport equipment				
Non-exporters	11.60	07.85	3.64	2.89
Exporters	39.36	59.69	28.79	46.14
All	50.96	67.54	32.43	49.03

We proceed further by calculating relative productivity indices for each of the industries under study distinguishing between sub-groups of exporting and non-exporting firms. The results given in Table 4.3 show that relative productivity was the lowest for exiting non-exporters. Instead exporting firms that exited during 2000-2005 did not universally have the lowest relative productivity compared to other sub-groups. When relative productivity indices were calculated for all the firms in the industry, relative productivity of exiting firms was still the lowest. In the contrary, entering firms tend to exhibit high relative productivity for both exporters and non-exporters in all four industries. The effect is less pronounced for entering exporters in *transport equipment* industry. Finally, both exporting and non-exporting firms that stayed in operating through 2000-2005 experienced modest growth in their relative productivity. However, the growth of relative productivity indices is higher for non-exporting continuing firms in three out of four industries (non-metallic minerals is an exception). Overall, the results confirm that all sub-groups of exporting firms tend to have higher relative productivity indices. Although as noted by Harris and Li (2009) the relative productivity indices have to interpreted carefully, “since they are simple arithmetic means that take no account of the relative size of each firm contributing to the overall mean value reported” [13].

Table 4.3. Relative Productivity. Separate Subgroups, 2000-2004.

	Continuing firms, (t-k)	Continuing firms, (t)	Entering firms, (t)	Exiting firms, (t-k)
Coke/chemical/nuclear				
Non-exporters	1.09	1.16	1.30	0.88
Exporters	1.07	1.07	1.43	1.15
All	1.08	1.13	1.33	0.93
Non-metallic minerals				
Non-exporters	0.85	0.84	1.02	0.66
Exporters	0.84	0.86	1.10	0.98
All	0.85	0.84	1.03	0.69
Machinery and equipment				
Non-exporters	0.73	0.82	0.95	0.62
Exporters	0.90	0.94	1.25	1.09
All	0.75	0.84	0.98	0.67
Transport equipment				
Non-exporters	0.31	0.43	0.44	0.19
Exporters	0.65	0.69	0.67	0.70
All	0.44	0.52	0.49	0.27

Note: Productivity indices are calculated relative to the average industry productivity index in 2000 based on equation (3.17) for each of the four industries and sub-groups considered.

We further compare the TFP distributions of exporting and non-exporting firms for each of the sub-groups of Haltiwanger (1997) productivity decomposition using Kolmogorov-Smirnov test[55]. The results of the test presented in Table 4.4 allow us to reject the null hypothesis that TFP distribution is favourable to non-exporting firms, confirming that TFP distribution of exporters lies to the right of that of non-exporters. Thus, we can conclude that TFP distribution of exporters dominates TFP distribution of non-exporters for each of the sub-group considered.

Table 4.4. Two Sample Kolmogorov-Smirnov Tests on the TFP Distribution by Sub-Groups, 2000-2005.

Sub-Group	**Difference Favourable To:**	
	Exporter	**Non-Exporter**
Continuing firms (*t*)	-0.0154	0.2579***
Entering firms (*t*)	-0.0040	0.4332***
Exiting firms (*t-k*)	-0.0065	0.5156***

Note: The test is implemented for all four industries. However, the test gives the same results, when implemented for each of the four industries separately. *** Null is rejected at <1% level. t=2005; t-k=2000

Finally, we implement Haltiwanger (1997) decomposition following equation (3.18). The results presented in Table 4.5 show that in three out of four industries under study exporter's contribution to industry aggregate productivity growth was significantly higher than that of non-exporters (the only exception being machinery and equipment industry). At the same time the output shares of exporters have also increased slightly

[55] The routine is available in STATA 9 and STATA 11.

during 2000-2005 (Table 4.2). Only in coke/chemical/nuclear the exporter's share of output have decreased from 94.38 percent of the industry output in 2000 to 89.47 percent in 2005. Indeed, overall, exporters exhibit better performance almost in every sub-group, with only exception being new-exporters, whose contribution to aggregate industry productivity growth is lower than that of non-exporting entrants in two out four industries. In particular, in coke/chemical/nuclear industry contribution of non-exporting entrants is 0.44 as compared to 0.22 by new exporters (which constitutes 0.23 percent of the total contribution of exporters to coke/chemical/nuclear industry TFP growth); and in machinery and equipment industry contributions to aggregate TFP growth by entering exporters and non-exporters were 0.46 and 0.67 respectively. In percentage terms entering exporters' contribution constituted 0.58 percent per annum of the total contribution of exporters to the TFP growth in machinery and equipment industry.

Table 4.5. Decomposition of Productivity Growth, Separate Industries, 2000-2005.

	Total	**Within**	**Between**	**Covariance**	**Entry**	**Exit**
Coke/chemical/nuclear						
Non-exporters	0.50	0.07	-0.04	0.04	0.44	0.01
Exporters	0.96	0.51	-0.08	0.27	0.22	-0.04
All	1.46	0.58	-0.12	0.31	0.66	-0.03
Non-metallic minerals						
Non-exporters	0.53	0.27	0.01	0.09	0.12	-0.04
Exporters	0.83	0.31	0.001	0.05	0.49	0.02
All	1.36	0.58	0.01	0.14	0.61	-0.02
Machinery and equipment						
Non-exporters	0.99	0.30	0.03	0.06	0.67	0.07
Exporters	0.80	0.32	0.05	0.02	0.46	0.05
All	1.79	0.62	0.08	0.08	1.13	0.12
Transport equipment						
Non-exporters	0.33	0.13	-0.09	0.27	-0.02	-0.04
Exporters	1.11	0.33	-0.09	0.38	0.54	0.05
All	1.44	0.46	-0.18	0.65	0.52	0.01

Note: Figures reflect percentage increase per annum

Overall the results for the four industries show that the largest contribution to the aggregate productivity growth comes from advances in productivity of continuing firms (Within component) for both exporting and non-exporting sub-group. The "between component" that indicates redistribution of resources between continuing firms is relatively low and sometimes even negative for both exporting and non-exporting firms, confirming that there was not much resource redistribution across continuing firms in both exporters' and non-exporters' sub-groups. On the other hand, the covariance term indicates that large exporting firms have increased their productivity along with their market shares in transport equipment and coke/chemical/nuclear industries. In transport equipment industry large non-exporting firms have also increased their productivity along with their market shares (0.27 percent per annum). Finally, both exporting and non-exporting exiting firms have low productivity in most of the cases, which results into the overall positive impact on the aggregate industry productivity growth.

Table 4.6. Decomposition of Productivity Growth, Various Studies

	Bernard and Jensen (2004c), Table 8			*Hanson and Lundin (2004), Table 10*				
Data and Period	US LRD, 1983-92			Sweden, 1990-99				
Sector	Manufacturing			Manufacturing				
Decomposition method	'Within' and 'Between' effects only			'Within' and 'Between' effects only				
Methodological features	Uses balanced panel so excludes entry and exit			Uses balanced panel so excludes entry and exit				
Productivity measures	TFP			TFP				
Main results:	(% p. a.)			(% p. a.)				
	Within	**Between**	**Total**	**Within**	**Between**	**Total**		
Non-exporters	0.76	-0.48	0.28	1.5	-4.2	-2.7		
Exporters	0.07	1.07	1.14	4.0	2.1	6.1		
Total	0.83	0.59	1.82	5.5	-2.1	3.4		
	Baldwin and Gu (2003), Table 13			*Harris and Li (2008), Table 6*[*]				
Data and Period	Canadian ASM, 1974-96			UK FAME, 1996-2004				
Sector	Manufacturing			All market based sectors				
Decomposition method	Within + Between' and entry only			'Within', 'Between', 'covariance', entry (mergers and new firsm separately) and exits				
Methodological features	Assumes exits replace entrants (no separate role for exits)			Uses unbalanced panel weighted to ensure representative of UK firms.				
Productivity measures	TFP			TFP				
Main results:	(% p. a.)			(% p. a.)				
	Within+ Between	**Entry**	**Total**	**Within**	**Between**	**Entry**	**Exit**	**Total**
Non-exporters	3.6	-0.9	2.7	0.04	0.16	-0.13	0.74	0.81
Exporters	79.3	18.0	97.3	0.42	0.29	0.96	-0.39	1.27
Total	82.9	17.1	100	0.46	0.45	0.83	0.35	2.09

Source: Harris and Li (2008), p. 231, Table 7. *The 'covariance' term is added to 'between', and 'mergers/takeovers' is added to 'entry' from Table 6 to obtain the results in Table 7.

Finally I would like to compare the results of the current study with the results from other studies in the area. Although, in the current framework we implemented productivity decomposition for four separate industries it would still be interesting to see whether other studies that distinguish between exporting and non-exporting firm arrive at the same conclusions. The summary of the results of several studies that distinguish between exporting and non-exporting sub-groups of firms are provided in Table 4.6 adopted from Harris and LI (2009). Authors note that it is hard to make comparisons between different studies as they all use different methods of productivity decomposition, different countries and not comparable time-periods. However, majority of the studies do confirm that exporting firms account for a larger share of aggregate productivity growth in manufacturing sectors and in all market sectors.

4.5.3.2 Quantile regressions

We proceed now to the analysis of the relationship between the dynamics of the firm-level exporting activity and its productivity performance on the intensive margin, I continue to focus on continuous exporters and define three types of exporting behaviour:

- ✓ Move down – firms moving into a lower decile of the industry-specific export distribution
- ✓ Move up - firms moving into a higher decile of the industry-specific export distribution
- ✓ Stay – firms that do not change their relative position in the industry-specific distribution of exports.

Column (1) of Appendix 4.10 presents the results of OLS regressions of changes in TFP as a function of these three types of export dynamics[56]. The results of the regression analysis show the presence of correlation between firms' exporting activity and their productivity performance. Continuous exporters which reduce their export volumes suffer a noticeable decline in the TFP: the constant terms are negative and highly significant (between -0.3 and -0.8) in all four industries. The coefficients for both 'stay' and 'move up' are positive and significant in all industries. However, the results of the F-test refute the hypothesis that coefficients of 'move up' are significantly higher than those of 'stay' in all four industries, which means that productivity gains from 'move up' and 'stay' are roughly equal.

The relationship between firm-level productivity performance and its exporting dynamics is a result of highly heterogeneous firm behaviour. In order to compare the distribution of the TFP changes for the firms with different types of exporting dynamics across the four industries under study, I use kernel density estimation[57]. Appendix 4.11 compares firms that move down, move up and do not change their relative position in the distribution of exports for each of the four industries. The distributions are

[56] The model also includes time and region dummies.
[57] See Appendix 4.17 for details of the kernel density estimation.

significantly different. In all four industries, the distribution of the TFP changes for the firms that *move down* the ladder of export distribution *stochastically dominates* the distribution of the TFP changes of the firms that *do not change* their relative position in the industry-specific distribution of exports. Furthermore, the distribution of the TFP changes of the firms that *do not change* their relative position in the industry-specific distribution of exports stochastically dominates the distribution of the TFP changes for the firms that *move up* in the industry-specific distribution of exports. In other words, for any level of TFP change, the cumulative distribution function (CDF) has the highest values for the firms that *move down* and the smallest values for the firms that *move up* in the distribution of exports.

We proceed with the analysis of the impact of changes in export volumes on the firm-level TFP for the firms with different types of exporting dynamics (firms that move up, stay and move down in the industry specific export distribution). For this purpose I employ quantile regressions that make it possible to observe differences in the impact of changes in export volumes on the firm-level productivity, depending on a firm's place in the industry-specific export distribution. Since all firms would now fall in one of the 10 percentiles, we can see how the impact differs for large, medium and small exporters. I estimate quintile regressions using routines available in STATA 11 including region and year dummies to control for the fixed region and year effects. According to the design of the distribution, firms are allowed to move between quintiles over time, which could be a source of additional bias in the regression. However, as shown in figure Figure 2.1, percent of firms that change their position in the industry specific export distribution is relatively low, which makes us conclude that this issue should not pose a significant problem in this case.

Quantile regression coefficients are interpreted as partial derivatives of the conditional quantile function with respect to the regressors. For example, having obtained a positive coefficient for an independent variable in the regression for the 1st decile, one can conclude that a one-unit increase in this regressor will increase the 1st decile of the dependent variable distribution by the value of the coefficient.

The results of quantile regressions of the TFP changes as a function of the type of the export dynamics for each of the four industries for 9 quantiles (each containing 10% of the distribution of the dependent variable) are presented in columns (2) to (10) of Appendix 4.10.

The findings show that coefficients for ‘stay’ and ‘move up’ are mostly significant for the middle deciles, columns (4)-(7). These findings, support the hypothesis that most of the export gains appear in the long term, when a firm becomes a relatively larger exporter and adjusts to the international market conditions. New entrants engaging in small scale operations are able to experience hardly any productivity gains immediately after entering export markets. Another ‘surprising result’ of the model is that the coefficient for ‘move down’ category in case of the large exporters that belong to the 90^{th} percentile is positive and highly significant, which implies that for this export group, decrease in export intensity results into higher productivity growth. As we discussed earlier, increase in exports leads to higher TFP growth only for the firms in 50^{th} -70^{th} percentile, in other words for the firms that are in the middle of export distribution. However, we do not observe any positive productivity effects from increases in export volumes for the firms in the 70^{th}-90^{th} quintiles in three out of four estimated industries. One of the possible explanations stems from the theory of dynamic employment and investment decisions under uncertainty (Hammermesh and Pfann, 1996; Dixit, 1989, 1992, 1997; Bentolila and Bertola, 1990), according to which, firms in the 70^{th}-90^{th} percentiles might not be at their optimal input levels. And, reduction in their export (and at the same time production) volumes, which would simultaneously reduce their input requirements, would have a positive impact on their TFP.

In order to gain a deeper understanding of the relationship between exporting activity and its productivity gains, I will try to distinguish between different types of export markets. A common logic would imply that a firm which starts exporting to a more technologically advanced country will eventually benefit from productivity gains owing to the access to new technologies, better managerial practices, etc. At the same time, companies which export mostly raw materials, semi-processed goods or any other labour-intensive goods would experience hardly any productivity gains attributed to exporting, owing to the simple production process.

In order to test this hypothesis and study this phenomenon in more detail, I focus on different types of exporting markets and export products. First I focus on firms exporting to the countries of the European Union (EU) versus firms exporting to the countries of the Commonwealth of Independent States (CIS). Furthermore, I continue the analysis by distinguishing between different types of export products (i.e. raw materials versus finished products) exported to the technologically advanced market of the EU.

The results of the quantile regressions of the TFP changes as a function of the type of the EU-export dynamics for each of the four industries are presented in the Appendix 4.12. The results show that the coefficients for both ‘stay’ and ‘move up’ are positive and significant for most of the quantiles in the coke/chemical/nuclear and machinery and equipment industries, and for the middle quantiles in the transport equipment industry. In the non-metallic minerals industry, the coefficient for ‘stay’ is only significant for the sixth quantile, and the coefficient for ‘move up’ is significant for all quantiles except the 1st.

Appendix 4.13 presents the results of the quantile regressions of the TFP changes as a function of the export dynamics with a concentration on the CIS export market. Apart from a few exceptions, the coefficients for ‘stay’ and ‘move up’ are positive and significant in all industries and quantiles.

At first glance, the results reveal the benefits in exporting to both the EU and the CIS markets. However, the relative size of the coefficients is higher for the products exported to the EU market. Indeed, for all industries, the coefficient for variables ‘stay’, ‘move up’ and ‘move down’ are usually 1.5-2 times higher in the case of the exports to the EU market. The difference in the size of coefficients increases significantly in the 4th to 9th decile. This might mean that established exporters that have already adjusted to market conditions and reached sufficient levels of export volumes benefit even more from exporting to the more advanced markets of the EU.

Next I use more detailed product information, and distinguish between capital-intensive versus labour-intensive products and raw materials in order to test whether there is a significant difference in productivity gains from exporting the former versus the latter.

The results of the quantile regressions of the TFP changes as a function of the EU-oriented export of different types of products selected from the four industries are presented in Appendices 4.14, 4.15 and 4.16.

Overall, the results confirm the initial hypothesis suggesting higher benefits from the exporting of capital intensive goods to the technologically advanced markets. For example, the coefficients for ‘stay’ and ‘move up’ are mostly statistically insignificant for export products such as rubber and rubber goods, tools and cutlery, plastic and plastic goods, aluminium and aluminium products, goods made of stone, cement, gypsum, asbestos, mica and similar materials, precious metal products (jewelry), ceramic products, glass and glass products, mineral fuel, oil and processed products, non-organic chemical products, organic and non-organic compounds of precious and rare-earth metals, isotopes and radioactive elements, organic chemical compounds, and fertilizers.

It is surprising that coefficient for 'stay' and 'move up' are positive and significant for most of the deciles for products such as salt and sulphur, wood, wood products and charcoal. However, in this case, such benefits from exporting can be explained by economies of scale, since these products are produced by the firms characterized by the high levels of output and correspondingly high export volumes from the very beginning of exporting activity.

Finally, the results of the same analysis for the capital intensive goods presented in the Appendix 4.16 are quite mixed, and do not allow any clear judgment about benefits of exporting to the more technologically advanced market of the EU. For example, exporting nuclear reactors, boilers, supporting mechanic equipment and its parts leads to a significant increase in productivity growth. On the other hand, exports of the electric, sound and TV recording and audio equipment and parts, transport vehicles (except rail transport), optic, photographic, cinematographic equipment, meters, and check meters lead to the increase in productivity growth for only some deciles of the export distribution, mainly (1)-(4), with no clear productivity benefits being associated with further increase in the export volumes.

Overall, the results of the analysis imply that firms increasing their export volumes are more likely to experience higher increases in productivity, compared with firms that do not change or move down in the industry-specific distribution of exports. Significant productivity gains are more likely to appear after the initial entry period has passed and the firm has adjusted to the international market environment and become a medium or a large exporter. Also, the productivity gains tend to be higher when firms concentrate on exporting to the more technologically advanced and economically developed markets. In some cases, higher benefits do occur in the case of exporting of technology-intensive products to the more economically developed markets; however, current findings do not provide a sufficient evidence base for a non-controversial conclusion on this matter.

4.6. Summary

In this paper I have used panel data on the four Ukrainian manufacturing industries to study the relationship between exporting activity and productivity performance at firm level. For this study, I used the data of the four most export-intensive Ukrainian industries for the period 2000-2005.

First, I concentrated on the analysis of the exporting activity on the firm level and showed that most of the entries and exits take place at the bottom of the industry-specific export distribution. New exporters usually start their international activity with small-scale exporting operations, and the firms that exit the export markets are typically small exporters. In all industries, exporting firms are very different; however in each of the industries, the top 10% of exporters account for about 80% of total industry exports, and their export sales volume and export intensity are much higher than the industry average.

The dynamics of the exporting activity at the intensive margin is also quite intense: firms move up and down the export distribution, gradually changing their position. One of the main conclusions of the current chapter is that the mobility of firms across the industry-specific export distribution has an inverted-J shape. Firms in the bottom and middle percentiles of the export distribution are more likely to change their relative position in the distribution of exports than those firms located at the top of the ladder. However, the results for Ukrainian data imply that the probability of large exporters to change their relative position in the export distribution is still quite high, about 70%, compared with that of 90% in lower deciles.

The second part of the chapter is focused on the analysis of the relationship between exporting dynamics and productivity performance. In this study, I distinguished between export dynamics at the extensive and intensive margin. The extensive margin accounts for entries into and exits from the export markets, and the intensive margin takes into account the firms that export in consecutive years.

The results of the analysis show that entries and exits account for a small percentage of the gross industry changes in employment, output, exports and productivity.

The results of the standard OLS regressions reveal that, on average, an increase in a firm's export intensity is associated with the TFP gains and decrease – with the TFP losses. These findings are further confirmed by the results of the kernel density estimation (Appendix 4.11) of the distribution of the yearly TFP changes, and by the results of the quintile regressions which also show that an increase in the firm's export intensity is associated with a superior distribution of the yearly changes in the TFP, which means that such firms are more likely to experience higher productivity gains, compared with the firms that keep or decrease their export intensity.

However, the results reveal a high level of heterogeneity. One of the interesting findings is that realisation of the TFP gains appears mostly in the long term, when a firm has managed to approach the middle of the export ladder.

Next, in order to gain a deeper understanding of the relationship between exporting dynamics and productivity gains, I distinguished between different types of export markets and products. Here I tested the hypothesis that a firm exporting to the more technologically advanced country would eventually experience higher productivity gains owing to the access to new superior technologies, better managerial practices, etc.

At the same time, I tested if there is a significant difference in the productivity gains from exporting of labour-intensive versus capital-intensive products to the more economically developed markets. For this purpose, I concentrated on exports to the markets that include countries of the European Union and countries of the Commonwealth of Independent States. The results are similar to the general quantile regression results, and once again confirm that:

- ✓ firms that increase their exports - especially to the technologically advanced markets - are more likely to experience higher productivity gains;
- ✓ productivity gains are usually realised in the long term, after the firm has adjusted to the international market conditions;
- ✓ productivity gains/losses are higher in the case of exporting to the markets possessing higher levels of economic development;
- ✓ in some cases, productivity gains/losses are higher in the case of exporting of capital intensive products to the markets with higher levels of economics development.

Overall, the results of the study are consistent with the predictions of the theoretical models of exporting dynamics in industries with heterogeneous firms and sunk costs of exporting (Bernard *et al.,* 2003; Melitz, 2003; Helpman, Melitz and Yeale, 2004) and models of firm's dynamic employment and investment decisions under uncertainty (Bentolila and Bertola 1990, Hammermesh and Pfann 1996, Dixit 1989).

First of all, we have to account for a range of inaction that occurs prior to the entry into the export market. Most of the firms that consider a possibility of exporting would be stifled by the significant sunk entry costs, which might postpone their entry or prevent it altogether. The inaction gap is further magnified by the uncertainty about the export market conditions: a firm might have imperfect information about the potential demand for its product on the foreign market (static market conditions), or might encounter sudden changes in the foreign demand or exchange rates (dynamics changes in market conditions). Thus most of the responses to changes in the market conditions come from incumbent exporters. This statement is confirmed by the current findings which show that entries and exits from the export market account for about 10-12.5% of the gross industry changes in exports only.

Next the ladder export structure with new exporters engaging in a small scale operations suggest that entrants experience not only the sunk entry costs of exporting but also increasing convex-shaped post-entry exporting costs. Hammemesh and Pfann (1996) showed that, when expanding/contracting its exporting activity, a firm can incur monetary and nonmonetary costs of labour adjustment, like hiring, firing and training, and costs of buying/installing new equipment and associated workforce training costs.

This theory also explains the fact that the mobility of firms across the deciles of export distribution has an inverted J-shape. The logic behind it implies that an increase in export sales would imply a significant rise in export adjustment costs; thus only the most productive firms would manage to bear these costs and reach the top of the export ladder. Also, owing to the size of the export adjustment costs, firms at the top of the distribution would be less likely to change their relative position (due to the wide region of inaction). Both these facts explain the lower mobility of large exporters.

Overall, our findings explain the results of the previous chapter, which provided mixed evidence of the statistically significant productivity gains for the new exporting firms in the post-entry period. The results of the current chapter show that new exporters usually engage in a small scale exporting operations because of imperfect market information, high entry sunk costs and dynamic export adjustment costs. Thus the majority of the entries into and exits from the export markets take place at the bottom of the export ladder, and lead to relatively small gains/losses in the TFP. Often much higher TFP gains appear only at a stage when a firm adjusts to the new international economic environment, and expands its exports sufficiently to become a large exporter, or at least to reach the middle of the industry exports distribution.

4.7. Appendix. Number of exporting firms and export sales by industry, 2000-2005

Industry		2000	2001	2002	2003	2004	2005	2000-2005 Change (%)
Coke/chemical/nuclear	Exporters	231	266	279	292	327	273	42.0
	% of total	26.22	22.06	21.49	22.62	24.85	22.34	18%
	Export sales	0.74	1.06	1.08	2.74	4.20	2.00	1.3
	% of total	5.21	6.49	4.73	7.88	12.02	4.30	170%
	Domestic sales	13.45	15.28	21.79	31.98	30.74	44.48	31.0
	% of total	94.79	93.51	95.27	92.12	87.98	95.70	231%
Non-metallic minerals	Exporters	202	249	265	300	312	275	73.0
	% of total	10.78	11.39	11.52	12.94	12.91	12.38	36%
	Export sales	0.13	0.16	0.15	0.41	0.58	0.55	0.4
	% of total	2.75	2.82	2.47	3.71	18.30	14.95	323%
	Domestic sales	4.60	5.56	6.08	10.56	2.58	3.14	-1.5
	% of total	97.25	97.18	97.53	96.29	81.70	85.05	-32%
Machinery and equipment	Exporters	562	605	628	681	733	658	96.0
	% of total	17.27	15.19	15.10	16.00	17.13	17.11	17%
	Export sales	0.44	0.61	0.63	1.34	1.03	0.73	0.3
	% of total	4.85	5.60	5.35	7.33	13.84	8.86	65%
	Domestic sales	8.69	10.33	11.11	16.93	6.44	7.52	-1.2
	% of total	95.15	94.40	94.65	92.67	86.16	91.14	-13%
Transport equipment	Exporters	164	185	196	207	231	195	31.0
	% of total	22.44	22.67	22.63	24.32	26.25	22.62	19%
	Export sales	0.33	0.39	0.51	0.72	1.08	0.59	0.3
	% of total	5.71	5.53	5.70	6.44	5.87	3.53	79%
	Domestic sales	5.44	6.60	8.50	10.42	17.27	16.14	10.7
	% of total	94.29	94.47	94.30	93.56	94.13	96.47	197%
Total	Exporters	1159	1305	1368	1480	1603	1401	242
	% of total	17.20	15.93	15.86	16.98	18.03	17.19	21%
	Export sales	1.64	2.22	2.38	5.20	6.89	3.87	2.2
	% of total	4.86	5.55	4.77	6.93	10.78	5.15	136%
	Domestic sales	32.18	37.76	47.48	69.88	57.03	71.28	39.1
	% of total	95.14	94.45	95.23	93.07	89.22	94.85	121%

Note: domestic sales and export sales are expressed in billion USD

4.8. Appendix. Firms' export dynamics, 2000-2005, yearly transitions

Industry		**2000-2001**	**2001-2002**	**2002-2003**	**2003-2004**	**2004-2005**
Coke/chemical/nuclear	Exit (% of total)	0.41	0.31	0.31	0.23	0.08
	Start export (% of domestic)	16.0	6.7	7.0	7.8	5.5
	Stop export (% of exporting)	11.3	3.8	1.4	2.4	1.2
	Increase exports >25%	35.1	23.3	46.2	40.1	27.2
	Decrease exports <25%	66.2	62.4	47.3	51.7	36.7
Non-metallic minerals	Exit (% of total)	1.4	1.0	0.5	0.1	0.0
	Start export (% of domestic)	6.6	4.0	4.3	3.9	2.6
	Stop export (% of exporting)	15.8	7.2	4.5	3.0	1.3
	Increase exports >25%	35.1	28.1	43.8	35.7	28.2
	Decrease exports <25%	67.3	64.7	57.4	46.3	39.7
Machinery and equipment	Exit (% of total)	0.6	0.5	0.2	0.2	0.01
	Start export (% of domestic)	8.7	4.7	4.7	4.7	3.3
	Stop export (% of exporting)	17.4	8.8	3.3	1.3	0.8
	Increase exports >25%	32.7	22.6	44.4	41.0	28.1
	Decrease exports <25%	59.6	62.8	50.3	50.1	42.7
Transport equipment	Exit (% of total)	0.37	0.7	0.5	0.3	0.1
	Start export (% of domestic)	12.2	7.1	7.9	9.6	6.0
	Stop export (% of exporting)	15.2	5.4	2.6	1.4	2.2
	Increase exports >25%	35.4	26.5	40.3	30.0	26.8
	Decrease exports <25%	62.2	61.1	53.6	65.2	43.7

4.9. Appendix. Exporting activity in 2001

Deciles of export distribution	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
					A. Ratio of firm to industry average export sales					
Coke/chemical/nuclear	0.00	0.01	0.03	0.07	0.14	0.27	0.66	1.29	3.74	38.54
Non-metallic minerals	0.03	0.08	0.14	0.26	0.51	0.95	1.72	3.39	7.36	73.20
Machinery and equipment	0.02	0.05	0.10	0.18	0.37	0.65	1.13	2.42	5.71	55.59
Transport equipment	0.01	0.03	0.07	0.14	0.26	0.49	0.85	1.86	5.07	34.57
					B. Export intensity (%)					
Coke/chemical/nuclear	0.01	0.03	0.06	0.15	0.29	0.60	1.40	2.74	8.26	85.05
Non-metallic minerals	0.03	0.09	0.15	0.29	0.56	1.09	1.83	3.90	7.81	80.92
Machinery and equipment	0.02	0.08	0.15	0.27	0.56	0.97	1.68	3.65	8.60	82.36
Transport equipment	0.02	0.07	0.15	0.31	0.59	1.07	1.95	4.03	10.99	79.14
					C. Export share (%)					
Coke/chemical/nuclear	0.01	0.03	0.06	0.15	0.30	0.61	1.42	2.78	8.38	86.28
Non-metallic minerals	0.03	0.09	0.15	0.30	0.58	1.13	1.89	4.03	8.08	83.71
Machinery and equipment	0.03	0.08	0.15	0.28	0.57	0.98	1.71	3.71	8.75	83.75
Transport equipment	0.02	0.07	0.15	0.31	0.60	1.09	1.98	4.10	11.18	80.50

4.10. Appendix. Quantile regressions: Yearly changes in TFP as a function of exporting dynamics

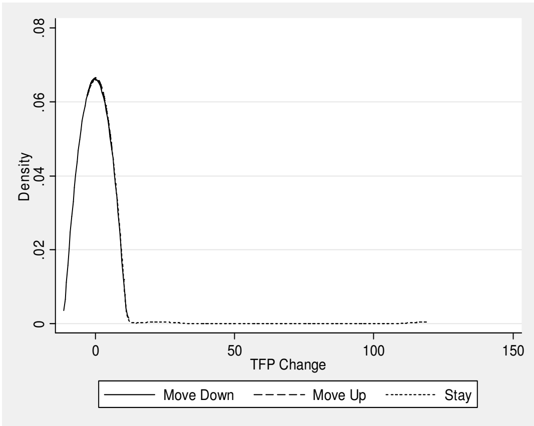
Variable	OLS	Percentile								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Coke/chemical/nuclear										
Constant/Move down	-0.754***	-1.173***	-0.593***	-0.331***	-0.278***	-0.159**	-0.0661	0.0431	0.196	0.559***
Stay	0.368**	0.208	0.138	0.011	0.068	0.090	0.107	0.076	0.050	-0.033
Move up	0.502**	0.352	0.363*	0.111	0.142**	0.148**	0.144**	0.148*	0.243*	0.367*
F-Test (No changes=Increase)	0.63	0.51	5.5***	2.01*	1.21	1.16	0.48	1.03	3.02*	3.29*
Non-metallic minerals										
Constant	-0.318	-1.107**	-0.617***	-0.352***	-0.305***	-0.205***	-0.0758	0.00109	0.192	0.582**
Stay	0.421*	0.213	0.166	0.0539	0.118*	0.143**	0.106	0.106	0.0245	0.0747
Move up	0.462*	0.275	0.343*	0.109	0.135*	0.154**	0.129*	0.0731	0.0369	0.0347
F-Test (No changes=Increase)	0.04	0.08	2.61*	0.62	0.06	0.03	0.23	0.26	0.02	0.23
Machinery and equipment										
Constant/move down	-0.881***	-1.180***	-0.654***	-0.354***	-0.311***	-0.203***	-0.110	0.0224	0.189	0.624**
Stay	0.457*	0.332	0.171	0.0515	0.114*	0.137**	0.143**	0.0899	0.0433	-0.0046
Move up	0.499*	0.330	0.322	0.103	0.126*	0.162**	0.153**	0.0475	0.0563	0.0267
F-Test (No changes=Increase)	0.04	0	1.6	0.33	0.02	0.18	0.03	0.47	0.01	0.02
Transport equipment										
Constant/move down	-0.348	-1.141**	-0.626***	-0.352***	-0.298***	-0.190**	-0.0894	0.0219	0.193	0.609**
Stay	0.443*	0.332	0.166	0.0326	0.111*	0.133**	0.121	0.0925	0.0399	-0.0316
Move up	0.484*	0.350	0.311*	0.105	0.114	0.140*	0.136*	0.0556	0.0433	-0.00352
F-Test (No changes=Increase)	0.04	0.01	1.36	0.74	0	0.01	0.11	0.34	0	0.02

Notes: Dependent variable: year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year.

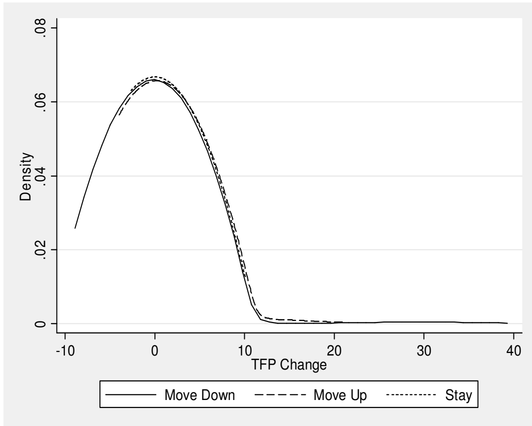
***Significant at 99% level; **Significant at 95% level; *Significant at 90% level. Model also includes year and region dummies.

4.11. Appendix. Kernel density estimation graphs

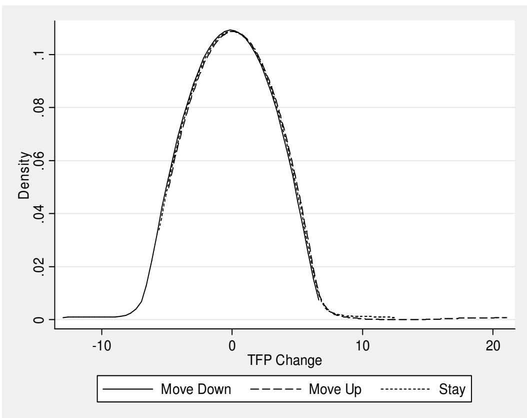
Non-metallic minerals



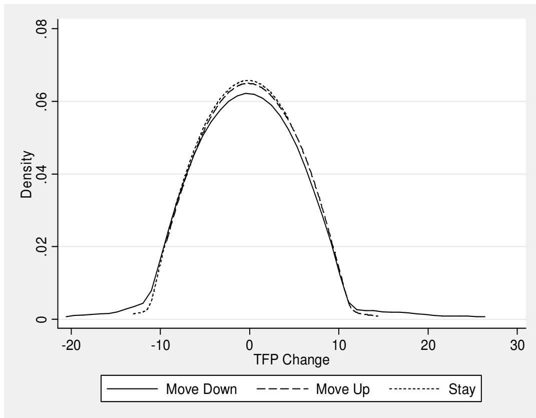
Machinery and equipment



Coke/chemical/nuclear



Transport equipment



4.12. Appendix. Quantile regressions: Yearly changes in TFP as a function of exporting dynamics by destination: European Union (EU)

Variable	OLS -EU	Percentile-EU								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Coke/chemical/nuclear										
Constant/move down	-1.485*	-4.072***	-2.121***	-0.881**	-0.739***	-0.537**	-0.136	-0.008	0.320	0.415
Stay	2.162***	0.859	0.703	0.316	0.586***	0.680***	1.064***	1.431***	2.072***	5.053***
Move up	1.147	1.303**	1.247**	0.559	0.800***	0.795***	0.948***	0.934***	1.103***	1.643***
Non-metallic minerals										
Constant	-0.504*	-1.478***	-1.412***	-0.798***	-0.571***	-0.458***	-0.154	-0.0663	0.0228	0.204
Stay	0.234	0.172	0.298*	0.178	0.169	0.225*	0.0371	0.0405	-0.0134	0.372
Move up	0.430	0.152	0.415**	0.277**	0.345**	0.528***	0.333	0.389*	0.712***	0.837*
Machinery and equipment										
Constant/move down	-0.549**	-1.844***	-1.254***	-0.959***	-0.722***	-0.494***	-0.187	-0.0626	0.285	0.558**
Stay	0.554**	0.351	0.284	0.332*	0.369**	0.442***	0.289*	0.360**	0.578***	0.618*
Move up	0.798***	0.881*	0.698***	0.572***	0.587***	0.667***	0.523***	0.534***	0.738**	0.774*
Transport equipment										
Constant/Move down	4.090	-2.850	-1.718***	-1.349***	-0.822**	-0.467	-0.298	-0.0273	-0.0273	4.333
Stay	-0.122	0.172	0.227	0.450	0.662**	0.575*	0.746*	1.192**	1.873**	2.022
Move up	4.765	1.659	0.940	0.913**	0.782**	0.625*	0.786**	0.867	0.939	0.470

Notes: Dependent variable: year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year. ***Significant at 99% level; **Significant at 95% level; *Significant at 90% level. Model also includes year and region dummies.

4.13. Appendix. Quantile regressions: Yearly changes in TFP as a function of exporting dynamics by destination: Commonwealth of Independent States (CIS)

Variable	OLS -CIS	Percentile-CIS								
		10	20	30	40	50	60	70	80	90
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Coke/chemical/nuclear										
Constant/move down	-1.485*	-4.244***	-2.173***	-1.169***	-0.521**	-0.312**	-0.0215	0.251	0.443*	1.151**
Stay	2.162***	2.448**	1.589***	0.808**	0.446**	0.417***	0.374***	0.393***	0.685**	1.423***
Move up	1.147	2.598*	1.636***	0.891**	0.786***	0.697***	0.533***	0.558***	0.733**	1.622***
Non-metallic minerals										
Constant/move down	-0.504*	-1.491***	-0.953***	-0.695***	-0.502***	-0.355***	-0.173*	-0.000261	0.224**	0.563**
Stay	0.234	0.812**	0.499**	0.353***	0.226**	0.196*	0.120	0.0643	0.0488	-0.101
Move up	0.430	0.621	0.263	0.322**	0.310**	0.392***	0.297***	0.270***	0.369**	0.584
Machinery and equipment										
Constant/move down	-0.549**	-1.561***	-0.905***	-0.570***	-0.402***	-0.269***	-0.118**	0.00891	0.128*	0.473***
Stay	0.554**	0.524***	0.370***	0.217***	0.227***	0.171***	0.125**	0.110**	0.135	-0.0170
Move up	0.798***	0.850***	0.568***	0.411***	0.389***	0.366***	0.407***	0.441***	0.520***	0.583***
Transport equipment										
Constant/move down	4.090	-3.580	-2.085***	-1.149***	-0.687***	-0.544***	-0.244	-0.0312	0.0782	1.100
Stay	-0.122	1.299	0.858**	0.496**	0.441***	0.444***	0.329**	0.400*	0.573**	0.237
Move up	4.765	1.140	0.876**	0.574***	0.536***	0.570***	0.366**	0.326*	0.317	0.0276

Notes: Dependent variable: year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year

***Significant at 99% level; **Significant at 95% level; *Significant at 90% level

4.14. Appendix. Raw materials and labour intensive products. Quantile regressions. Yearly changes in TFP as a function of exporting dynamics by product category and destination: European Union (EU)

Variable	Percentile-EU								
	10	20	30	40	50	60	70	80	90
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Code 25: Salt, sulphur,									
Constant	-7.284	-3.941***	-1.638*	-1.551**	-1.071***	-0.387	0.178	0.219	15.90*
Stay	0.466	0.777	0.567**	0.552***	0.554***	0.591**	0.611*	1.458**	2.084**
Move up	1.768	0.77	0.557**	0.739***	0.687**	0.967***	1.108**	1.859**	1.976
Code 44: Wood and wood products, charcoal									
Constant	-19.39***	-5.742**	-3.389***	-1.528***	-1.242***	-0.729***	-0.0083	0.483	4.719***
Stay	0.968***	0.720***	0.353***	0.249***	0.186***	0.0945	-0.0031	-0.0175	-0.845***
Move up	1.101***	0.914***	0.514***	0.413***	0.352***	0.290***	0.188***	0.264***	-0.273
Code 40: Rubber and rubber goods (tyres)									
Constant	-4.914**	-3.558***	-2.460***	-1.447***	-0.661*	-0.0028	0.0657	0.634	2.391
Stay	-0.627	0.533	0.447	-0.223	-0.079	-0.136	0.0187	0.238	-0.712
Move up	0.143	0.25	0.497	-0.115	-0.0757	-0.0249	0.00563	-0.739	4.24
Code 82: Tools and cutlery									
Constant	-7.675***	-4.882**	-2.095*	-2.196***	-1.237**	-1.026*	0.0479	4.899	37.24***
Stay	3.662	0.868	0.0825	0.183	0.0705	0.165	-0.526	-4.57	-36.64***
Move up	1.305	-1.082	-0.535	-0.434	-0.676	-0.0545	-0.679	-5.462	-37.27***
Code 39: Plastic and plastic goods									
Constant	-3.865	-2.134**	-1.303***	-0.861*	-0.24	-0.0716	0.852	2.507	5.154
Stay	-1.017	-0.312	0.181	-0.188	0.0458	0.246	0.569	1.613	-0.302
Move up	1.567	0.92	1.088**	0.586	1.033**	1.247**	1.909**	2.013	-0.41
Code 76: Aluminium and aluminium products									
Constant	-4.293	-3.112	-0.935	-0.672	0.103	1.304	2.227	4.015	13.06
Stay	1.748	1.6	1.249	1.205**	1.127*	0.856*	0.642	0.548	0.601
Move up	3.469	2.841	1.912	1.666**	1.373**	1.174*	1.2	0.907	1.797
Code 83: Precious metal products									
Constant	-1.499	-1.215	-0.92	-0.909	-0.624	-0.429	0.949	1.637	2.467
Stay	-1.378	-0.22	-0.209	0.192	0.445	0.401	0.512	0.548	0.548
Move up	-1.495	-0.142	0.602	0.811	0.88	1.354	1.249	2.555	15.21
Code 68: goods made of stone, cement, gypsum, asbestos, mica and similar materials									
Constant	-5.846	-2.773	-2.188	-1.374*	-0.971*	-0.900*	-0.911	0.175	0.175
Stay	2.703	1.27	1.117*	0.591	0.591	0.665	0.719	0.971	1.086
Move up	3.292	1.795*	1.840**	1.523**	1.222*	1.233	2.700*	3.157	12.08**

Notes: Year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year. ***Significant at 99% level; **Significant at 95% level; *Significant at 90% level

4.15. Appendix. Raw materials and labour intensive products. Quantile regressions. Yearly changes in TFP as a function of exporting dynamics by product category and destination: European Union (EU)

Variable	Percentile-EU								
	10	20	30	40	50	60	70	80	90
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Code 69: Ceramic products									
Constant	-2.316	-1.127	-0.699	-0.561	-0.421*	-0.315	-0.192	0.204	6.576*
Stay	-0.852	-0.0948	0.175	0.172	0.107	0.256	0.14	0.452	-5.43
Move up	0.0173	0.349	0.333	0.195	0.328	0.272	0.15	0.133	-5.847
Code 70: Glass and glass products									
Constant	-1.342*	-0.394	-0.17	-0.184	0.224	0.567***	0.567***	0.567	2.346
Stay	0.556	0.0101	0.257	0.271	0.339	0.0901	0.237	0.298	-0.0561
Move up	-1.612	-0.604	0.0716	0.346	0.508	0.545	1.453**	1.719	2.13
Code 27: Mineral fuel, oil and processed products									
Constant	-4.552	-3.243**	-0.832	-0.364	0.0194	0.0761	0.134	0.599	1.548
Stay	1.258	1.468	0.282	0.382	0.833	2.384***	2.979***	3.985**	4.134
Move up	0.376	0.736	0.206	0.763	0.419	1.137	1.272	2.087	2.772
Code 28: Non-organic chemical products; organic and non-organic compounds of precious and rare-earth metals, isotopes and radioactive elements									
Constant	-7.007***	-4.369***	-3.608***	-1.163	-1.329	-0.122	0.445	2.47	15.04
Stay	1.306	1.638*	1.158	0.0924	0.33	0.382	0.288	-0.194	-11.34
Move up	2.937***	2.143**	1.670*	0.748	1.094	1.457	0.824	0.741	-10.47
Code 29: Organic chemical compounds									
Constant	-2.818	-0.973	-0.676	-0.925	-0.886	-0.78	-0.851	-1.179	-0.845
Stay	-1.541***	-0.873**	-0.873***	-0.624	0.0448	0.682	1.314	2.618	2.187
Move up	-0.455	0.0241	-0.0171	-0.29	0.444	0.444	0.963	1.456	1.131
Code 31: Fertilizers									
Constant	-129.9**	-12.09	-12.09	-0.365	-1.96	-4.807	-6.033	-7.668	-5.709
Stay	121.0**	3.603	9.792	-1.481	0.309	3.256	5.034	7.835	8.152
Move up	108.2*	-10.3	-6.095	-5.018	-3.557	3.129	4.907	6.663	123.7
Code 39: Plastic and plastic goods									
Constant	-3.865	-2.134**	-1.303***	-0.861*	-0.24	-0.0716	0.852	2.507	5.154
Stay	-1.017	-0.312	0.181	-0.188	0.0458	0.246	0.569	1.613	-0.302
Move up	1.567	0.92	1.088**	0.586	1.033**	1.247**	1.909**	2.013	-0.41

Notes: Year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year. ***Significant at 99% level; **Significant at 95% level; *Significant at 90% level

4.16. Appendix. Capital intensive products. Quantile regressions. Yearly changes in TFP as a function of exporting dynamics by product category and destination: European Union (EU).

Variable Transport Equipment	Percentile-EU								
	10	20	30	40	50	60	70	80	90
	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Code 84: Nuclear reactors, boilers, supporting mechanic equipment and parts									
Constant	-4.914***	-2.296***	-1.132***	-0.575***	-0.211*	0.0699	0.442***	0.916***	2.665***
Stay	2.715***	0.932**	0.476**	0.176	0.118	0.0948	0.135	0.157	-0.587
Move up	2.564***	1.423***	0.920***	0.547***	0.475***	0.553***	0.882***	1.590***	9.587**
Code 85: Electric, sound and TV recording and audio equipment and parts									
Constant	-4.751***	-1.558***	-1.035***	-0.352	0.0806	0.477	1.762**	3.464***	4.767***
Stay	1.874	0.948*	0.733***	0.302	0.207	-0.0413	-1.148	-2.516***	-1.656*
Move up	0.808	0.247	0.443	0.276	0.193	0.575	0.196	-1.585***	0.505
Code 87: Transport vehicles except rail transport									
Constant	-3.751**	-1.745**	-1.428**	-1.115*	-0.158	0.122	0.0306	0.3	2.685
Stay	1.094	0.422	0.328	0.556	0.272	0.105	0.305	0.968	0.273
Move up	3.190**	1.906**	1.524***	1.616***	1.469	1.499	1.966	15.29**	14.99***
Code 90: Optic, photographic, cinematographic equipment, meters, and check meters									
Constant	-6.044***	-3.971***	-1.594	-0.41	-0.0406	0.0914	0.567	2.167	3.034**
Stay	4.137**	2.900***	1.182	0.269	0.085	0.338	0.337	-1.22	-0.384
Move up	3.447*	2.108**	0.0938	-0.147	0.105	0.49	0.691	-1.302	7.284

Notes: Year-to-year change in TFP. Each quantile (10-90) contains 10 percent of industry export distribution; quantiles are calculated each year. ***Significant at 99% level; **Significant at 95% level; *Significant at 90% level

4.17. Appendix. Kernel density estimation

Kernel density estimation is a non-parametric way to estimate the probability density function of a random variable. For example, if we have some data about a sample of a population, we can extrapolate this data to the entire population using kernel-density estimation.

Thus, the kernel-density approximation of a probability density function of an independent identically-distributed sample of a random variable ($x_1, x_2........, x_n \sim f$) is equal to

$$\tilde{f}_n(x) = \frac{1}{nh}\sum_{i=1}^{n} K\left(\frac{x - x_i}{h}\right)$$

where K is a kernel, i. e. a weighting function used in non-parametric estimation techniques, and h is a smoothing parameter called the bandwidth. It is common to assume K to be a standard Gaussian function with mean zero and variance 1. In that case, the variance is controlled indirectly through the parameter h:

$$K\left(\frac{x - x_i}{h}\right) = \frac{1}{\sqrt{2\pi}} e^{=\frac{(x-x_i)^2}{2h^2}}$$

Other density estimators, such as the histogram density estimator, are less smooth than the kernel density one. However, despite the fact that they can be made asymptotically consistent, they are often either discontinuous or they converge at slower rates than the kernel density estimator.

Intuitively, one can present kernel density estimator as the one placing small "bumps" at each observation, determined by the kernel function. The final estimator is a "sum of bumps" and is clearly smoother as a result[58].

[58] The material is adopted from Wikipedia [14] .

Chapter 5. Conclusions

Development of the modern growth theory redefined the role of productivity as a major driver of the economic growth; this was further confirmed by vast empirical evidence. The relationship between economic growth and technological change is quite complex and has recently gained significant attention in the literature. This dissertation has examined different aspects of technological change and productivity growth and their impact on the macroeconomic indicators. Productivity increase has become a cornerstone of many government and corporate policies. However, in a globalized world with the high share of international trade, investment and labour mobility, some government measures targeted at raising national productivity may have an adverse impact on various groups of economic agents in the rest of the world. Several complaints in this respect have resulted in a set of international legal arrangements preventing such negative effects. This issue is the focus of the analysis presented in Chapter 2.

Chapter 2 presents an endogenous growth model of sector productivity with piracy rate that makes it possible to account for varying levels of national IPR protection. In the case of a technology-producing country, higher levels of IPR protection should result in higher productivity growth. It is unclear, however, whether the same conclusion would hold in the case of a technology-importing country.

Chapter 2 explores this issue using the model of industry with monopolistic competition in a country that does not invest in innovation and depends entirely on technologies produced by the rest of the world. The first part of the model introduces the piracy rate into the model framework and studies its impact on sector productivity growth in a closed knowledge-producing economy. The results of the analysis suggest that higher levels of piracy rate are associated with higher levels of sectoral productivity growth rate. However, since the industry is populated with knowledge-producing firms, high levels of piracy rate would lead to the mass exit of firms from the market, thus leaving the sector completely empty, when $z = 1$. Owing to this adverse effect of piracy rate on the industry structure, positive impact of z on sector productivity growth is not sustainable in the long run.

The theoretical analysis is further extended into a two-country framework in which the *home country* produces no knowledge and depends entirely on the knowledge produced in the *foreign country*, acquiring it through legal purchases and knowledge spillovers. In this case, the results of the analysis indicate that the high levels of piracy rate associated with low levels of IPR protection are beneficial for the technology-consuming country. Moreover, higher levels of z , make the home-country industry more attractive, owing to higher levels of the free aggregate knowledge spillover stock; which results in a mass entry of new firms into the industry. This conclusion implies, that in a knowledge-consuming country low levels of IPR protection would result in a higher level of sector productivity growth which can be sustainable in the long run.

Thus the main finding of the model indicates that high levels of IPR protection can have an adverse impact on productivity growth in developing countries. The results of Chapter 2 can, to some extent, provide a rationale for the government policies of some developing countries which deliberately fail to bring national IPR legislation and enforcement in compliance with international standards.

The model specification presented in Chapter 2 provides a wide range of directions for further research. The assumptions of the current version of the model imply that all the knowledge produced in the *foreign country* eventually spills over to the *home country*. However, the model can be modified to assume that some portion of knowledge produced in the country never leaves its borders. Also, the international knowledge spillover rate can be modelled as a function of the country's openness to international trade and investment. Indexes of trade openness, like the Index of Trade Freedom provided by the Heritage Foundation and Wall Street Journal, can be used as proxy variables for this purpose. The model can also be modified to include several factors of production. It would also be interesting to calibrate the model using real data from developing countries and countries in transition. However, such an exercise is currently impossible owing to the lack of required longitudinal statistical data, especially in transition countries of Eastern Europe.

Chapter 3 shifts the focus of analysis towards exploring the relationship between international trade and productivity at micro level, using the database covering the main manufacturing and service sectors of the Ukrainian economy for the period 2000-2005. As discussed above, there are several ways through which international trade could be beneficial to the productivity growth of the firm and of the overall economy. The main aim of Chapter 3 is to study the ways in which exporting might influence a firm's performance and productivity at micro level.

In particular, Chapter 3 measures two main productivity effects associated with exporting. The first one occurs before entering export markets and is known as the self-selection effect. The main idea of the self-selection hypothesis is that only the most productive firms can become exporters owing to the significant amount of investment required to enter global markets. These investments are usually defined as sunk costs of exporting, and include investments in new product range and design, marketing, distribution, establishing foreign networks and others. The second effect, the so-called learning-by-exporting effect, occurs in the post-entry period. It states that firms operating in the international markets have better access to the new knowledge and technical expertise through their international contacts, which should ultimately result in further advances in their productivity.

The self-selection hypothesis is tested with the use of a probit model estimated separately for the 14 Ukraine manufacturing and 5 trade and service sectors. The results of the estimation are in line with previous findings in the literature on self-selectivity, and show that firms with higher TFP levels in the period *t-1* are much more likely to enter export markets in the period *t.* In addition, size, intangible assets and age of the firm have a significant positive influence of the probability of exporting.

Further analysis is focused on testing for the presence of the learning-by-exporting effect that usually occurs after the entry into overseas markets. For this purpose the propensity score matching technique was implemented, which allows accounting for the issues of endogeneity and sample-selection. The results of the analysis confirm the presence of the learning-by-exporting effect in the majority of the industries. However, the effect is not universal. Also, when the estimation is done for all of the firms in the dataset, the results suggest a substantial positive post-entry productivity effect for the firms that enter export markets for the first time in one and two years after entry. In order to reveal common trends in the results for separate sectors, the current finding are compared with those by Harris and Li (2008), who provide estimates for the 16 separate industries in the UK for the period 1996-2004.

Overall, results of the analysis confirm that differences in productivity between exporting and non-exporting firms can be partially attributed to higher productivity levels of exporters prior to entering export markets, and partially to the learning-by-exporting effect in the post-entry period.

There are several possibilities for further research in the area. The analysis can be performed for the different subsets of exporting firms, for example foreign ownership versus domestic ownership, older and younger firms. Another extension would be to distinguish the impact of different types of export markets on the magnitude of the learning-by-exporting effect, which is partly covered in 3.16.

Chapter 4 of the dissertation concentrates on the four main export-oriented Ukrainian industries, and widens the scope of analysis to explore the export-productivity nexus at the intensive margin (i.e. export intensity dynamics) which, according to recent theoretical findings, may have a higher impact on a firm's productivity than entries and exits from the export markets.

The analysis presented in Chapter 4 studies the structure and shape of Ukrainian export distribution, and estimates the impact of micro-export dynamics on the aggregate variables of exports, employment, output and productivity. Then the analysis concentrates on continuous exporters, and studies the impact of the type of exporting dynamics on the firm-level changes in the TFP, distinguishing between different types of export markets and export products. This allows us to test the hypothesis that an increase in exports to the more economically developed and technologically advanced markets leads to considerable gains in productivity for the exporting firms, especially in the case of capital-intensive products.

Overall, the results of the analysis performed in Chapter 4 provide an explanation for the mixed evidence of the statistically significant productivity gains for the new exporting firms in the post-entry period, found in Chapter 4. In particular, the results presented in Chapter 4 show that new exporters usually engage in a small scale exporting operations because of the imperfect market information, high entry sunk costs and dynamic export adjustment costs. Thus the majority of the entries into and exits from the export markets take place at the bottom of the export ladder, and are associated with relatively small gains in the TFP. Much higher TFP gains appear only at a stage when a firm adjusts to the new international economic environments and expands its exports sufficiently to become a large exporter, i. e. reaches the middle of the industry exports distribution.

The analysis of different types of export markets and export products confirms that exporting to the more technologically advanced countries results in higher productivity gains as a result of the access to new superior technologies and better managerial practices. Productivity gains can be higher when capital intensive products are exported to the economically advanced markets, such as the European Union.

Finally, it is worth noting that this dissertation has studied only a limited set of factors that influence aggregate productivity growth. The nature of the relationship between productivity and economic growth is complex, and many important aspects have not been addressed in this study. Overall, the area of productivity growth - especially in a developing country setting - has significant potential for further research.

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